COMPUTERS
AND MANAGEMENT

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TO MY MOTHER, IRENE

PREFACE

Much attention is now being focused on the computer by colleges presenting courses in business administration and economics. Junior colleges, senior colleges, and universities are teaching introductory courses in data processing; they are developing more advanced courses in systems analysis and program preparation; and they are incorporating the use of the computer in more traditional course offerings. This increasing attention being given to the computer is justified. Students destined to become managers in such functional business areas as accounting, finance, marketing, personnel, and production will find themselves working in an environment which will be significantly affected by the use of computer-based information systems.

In order to prepare for a successful working relationship with these computerized information systems, present and potential managers must (1) learn about the computer—what it is, what it can and cannot do, and how it operates—and (2) acquire an understanding of the managerial implications of computer usage.

Many introductory data-processing courses emphasize the first of these needs. Textbooks and/or manuals are used which are technically oriented and which are designed to provide the necessary grasp of hardware and programming concepts. Such courses are valuable and needed. But in them future managers are often not exposed to the broad impact which computers have had, are having, and may be expected to have on managers and on the organizational environment in which managers work.

The purpose of this book is to provide the broad managerial orientation which is needed. More specifically, this volume (1) explains *why* knowledge of information processing is required (and in so doing introduces readers to some basic information-processing concepts); (2) points out the *managerial implications* of computer usage to many whose data-processing preparation is not likely to be extensive; and (3) provides, in a single source, *relevant readings* taken from leading publications and written by respected authorities.

In Chapter 1, the subject of management information is examined. The data-processing steps necessary to produce such information are identified; the need for (and the importance of) management information is presented; and the desired properties of quality information are discussed. The concluding pages of the chapter are devoted to a study of the evolution of information processing.

Chapter 2 focuses attention on the information-processing revolution which is now under way. Topics treated in this chapter include (1) the revolutionary environmental changes which businesses are now facing and (2) the new information systems which are being developed to enable managers to cope with these rapid environmental changes. This chapter explains, in part, why future managers must have a knowledge of information processing.

Chapter 3 is an orientation chapter which presents a broad-brush treatment of the managerial implications of computer usage in the important areas of planning, decision making, organizing, staffing, and controlling. Chapters 4 through 7 expand upon the impact of the introduction and use of computers on the management job and on the business organization. The final chapter takes a look at what is ahead in management information systems.

Each of the eight chapters in this book is followed by several selected readings which supplement and/or expand upon the text subject matter. The chapters thus serve to establish a frame of reference for the readings which follow—a feature often missing in books containing readings. The readings have been chosen for their interest, content, and clarity of presentation.

Computers and Management requires no mathematical or data-processing background and is designed to be used (1) *in introductory data-processing courses,* where it will supplement the programming books and manuals used in technically oriented courses and where it can be used as a readings book regardless of the course orientation; (2) *in basic management courses,* where it will serve to impress upon management students the importance of the computer as a managerial tool; (3) *in introductory systems-analysis courses,* where it will expose potential analysts to the effects which their proposed systems changes are likely to have on managers and on the managerial environment; and (4) *by practicing managers,* who will find in this volume a concise presentation of current trends and future expectations in the area of business information systems.

It would be inappropriate to conclude these opening remarks without acknowledging the contributions of those who have improved the quality of this publishing effort. A special debt is owed to the publishers and authors who have granted permission for their materials to be used as readings in this book. Their individual contributions are mentioned in the body of the book.

Once again, I am grateful to Dean Ike H. Harrison and to the faculty of the M. J. Neeley School of Business, Texas Christian University, for their encouragement and support. I am also indebted to the Data Processing Management Association, publisher of my book entitled *Introducing Computers to Small Business,* for their permission to use appropriate quotations from that earlier work.

DONALD H. SANDERS

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INTRODUCTION

Let us begin this introductory essay by assuming that Madame Zelda, a local soothsayer, has achieved something of a marketing coup by persuading the class treasurer of a nearby college to invest the class funds in fortune-telling services for the entire group (the offer of a volume discount was an irresistible selling point). During the completion of this assignment, Madame Zelda foresees that some of the business students will be the future managers of information-processing departments making use of impressive computers. Most of the business students, on the other hand, are destined to become managers of such functional business areas as accounting, finance, marketing, personnel, and production.

Regardless of their particular occupational specialities, however, Madame Zelda predicts that all business students will be required to work in a future environment which will be significantly affected by computer-based information systems. To prepare for a successful working relationship with computerized information-processing systems, Zelda encourages each business student to establish the following personal goals: to (1) learn certain basic information-processing concepts and learn *why* knowledge of information processing is required, (2) acquire an understanding of the *managerial implications* of computer usage, and (3) learn where to find *additional information* about specific subjects. (This last goal takes into account the fact that the knowledge acquired by reading a few books or by enrolling in one or a few college courses will not be complete. Actions such as these, desirable though they are, represent the beginning of a continuing study.)

One can find little fault with the above predictions. Furthermore, Zelda's advice is both sound and timely for the managers of today and the student managers of tomorrow. Those who heed Zelda's advice may one day come to the conclusion that maybe the class treasurer wasn't quite as gullible as a number of the less tactful students had strongly implied!

PURPOSE AND ORGANIZATION

Simply stated, the basic objective of this book is to enable the reader to follow Zelda's advice. Stated another way, the primary purpose of this volume is to provide an insight into the broad impact which computers have had, are having,

and may be expected to have on managers and on the environment in which managers work.

The following chapters reflect this purpose. In Chapter 2 we shall examine the information-processing revolution now under way by looking at the revolutionary environmental changes facing businesses and the new information systems being developed to enable managers to cope with this rapid environmental change. This chapter will serve to establish why knowledge of information-processing concepts—Zelda's first goal— is required.

Chapter 3 is an orientation chapter which presents a broad-brush treatment of the managerial implications of computer usage in the areas of planning, decision making, organizing, staffing, and controlling. Chapters 4 through 7 expand upon the impact of computer usage on the management job and on the business organization. These chapters are directed at Zelda's second recommended goal. The final chapter takes a look at what is ahead in management information systems.

Following each chapter are selected readings which supplement and/or expand upon text matter. These articles, chosen for interest, content, and clarity of presentation, also serve to introduce the reader to publications which are recommended sources of further information, both now and in the future. Thus, the readings satisfy, in part, Zelda's third goal.

Students of business management should also have an understanding of the hardware characteristics of stored program computers, and of the procedures involved in the analysis and preparation of computer programs. These subjects are generally beyond the scope of this book but are treated in various levels of detail in a number of other books.[1] This text has been prepared, in part, to supplement hardware and programming books and manuals.

In the remaining pages of this chapter we shall examine more closely a very important subject—the subject of *management information*. We shall then briefly summarize the highlights of the *evolutionary development of information processing* before moving to Chapter 2 and "The Information-processing Revolution."

MANAGEMENT INFORMATION[2]

THE SCOPE OF INFORMATION

It has been observed that there are three elements fundamental to human activities. These elements are information, energy, and materials. It has further

[1] An orientation to the stored program computer—what it is, what it can and cannot do, how it operates, and how it is programmed—may be found in Chaps. 4 through 10 of Donald H. Sanders, *Computers in Business: An Introduction*, McGraw-Hill Book Company, New York, 1968.

[2] See the Reading "On the Nature of Management Information" at the end of this chapter for a detailed discussion of this subject.

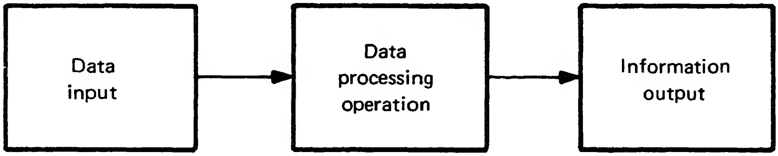
been observed that all of these elements are necessary to provide the physical things which humans need—e.g., food, clothing, shelter, and transportation. In addition to supporting physical production, however, information is also the substance of all man's intellectual activities; it is basic to education, government, literature, the conduct of business, and the maintenance and expansion of man's store of knowledge.

The economic scope and importance of knowledge based upon the generation and dissemination of information has been shown by Fritz Machlup. In 1958, Machlup estimated that 30 percent ($136 billion) of the United States GNP (gross national product) was expended on "knowledge."[3] An interesting follow-up study, using Machlup's criteria for "knowledge industries," showed that in 1963 knowledge expenditures had risen to 43 percent ($195 billion) of total national output![4] A significant factor in this phenomenal growth of the knowledge sector is the growth in, and the increased emphasis being placed on, the production and dissemination of management information.

MANAGEMENT INFORMATION DEFINED

Management information is relevant knowledge, produced as output of data-processing operations, and acquired to achieve specific purposes.[5] From this definition, we see that management information is the result of a transformation process. As Figure 1-1 shows, information is the output produced by manipulating input data.

FIGURE 1-1



[3] See Fritz Machlup, *The Production and Distribution of Knowledge in the United States*, Princeton University Press, Princeton, N. J., 1962. Machlup defined "knowledge industries" as those producing useful social information—i.e., knowledge industries were those engaged in education, communication, research and development, publishing and printing, entertainment, information-machine production, and related information services.

[4] See Gilbert Burck, "Knowledge: The Biggest Growing Industry of them All," *Fortune*, November, 1964.

[5] The above definition emphasizes management information in what might be termed the "formal" sense. Of course, managers also receive information from overheard conversations, from the actions rather than the words of others, and from other informal sources. In this informal sense, the manager processes the input data mentally and stores in his memory the information output for possible future use.

The word "data" is the plural of "datum," which means "fact." Data, then, are facts or informational raw materials, but they are not management information except in a constricted and detailed sense. Data are independent entities and are unlimited in number. The purpose of data processing is to bring order to them and place them in proper perspective so that meaningful managerial information will be produced. The primary distinction between data and information, therefore, is that while all information consists of data, not all data produce specific and meaningful information which will enable managers to plan, operate, and control their business activities.

What is the data-processing operation which produces information output? The nine basic steps of data processing are:

1 *Originating-recording* Data pertaining to relevant events or objects must be captured (*originated*) by measurement or collection. These data must then be *recorded* in a form which facilitates further handling—e.g., in the form of written *source documents*, such as sales slips, or on punched cards or magnetizable media.

2 *Classifying* Arranging data items with like characteristics into meaningful groups or classes is called *classifying*. Classifying is generally accomplished by a shortened, predetermined method of abbreviation known as *coding*. Alphabetic, numeric, or alphanumeric codes are used by designers of processing systems.

3 *Sorting* After coding the data, it is then often necessary to arrange or rearrange them in some arbitrary and predetermined manner. This arranging procedure is called *sorting*. For example, insurance agents are classified in the yellow pages of the telephone directory by type of insurance sold (auto, fire and casualty, life, etc.); within each insurance category the agents are then sorted into an alphabetical sequence.

4 *Calculating* The necessary arithmetic manipulation of the original data is known as *calculating*. It is interesting to note that while previous data-processing steps manipulate the original data, calculation results in new data or information.

5 *Summarizing* Reducing masses of data to a concise, effective, and more usable form is called *summarizing*. The president of a chain of retail stores may be interested only in total sales of particular outlets; to furnish him with sales figures for each store by department, by product, and by sales clerk would waste time and resources.

6 *Storing* Placing similar data into files for future reference is *storing*. Obviously, data should be stored only if the value of having them in the future exceeds the storage cost. Data are commonly stored on paper documents, microfilm, magnetizable media and devices, and punched paper media.

7 *Retrieving* Recovering stored data and/or information when they are needed for planning, operating, and controlling business activities is the *retrieving* step. Retrieval methods range from searches made by file clerks to the use of quick-responding stations which are connected directly (i.e., they are *online*) to

a computer. The computer, in turn, is connected directly to a mass-storage device which contains the necessary information. The computer is programmed to retrieve the information and relay it to the requesting station at electronic speeds. The station may be in the room next to the computer, or it may be 2,000 miles away. The subject of quick-response information systems will be covered more thoroughly in the next chapter.

8 *Reproducing* Copying or duplicating material is called data *reproduction* and may be accomplished by hand or by machine. Some machines produce a *hard copy* document which is directly readable by man; others reproduce the information in a machine-readable form, on such media as punched cards, punched paper tapes, and magnetic tape, so that it is difficult or impossible for man to read it directly.

9 *Communicating* The transfer of data from one operation to another for use or for further processing is known as data *communication*. The communicating process continues until the information, in a usable form, reaches the final user.

These, then are the basic steps in data processing. Figure 1-2 presents these steps and indicates some of the ways in which they are accomplished. The means of performing the steps vary, of course, according to whether manual, electromechanical, or electronic processing methods are used. Many businesses will find that the best solution to their processing requirements will be to use a combination of methods. For example, manual methods will be used for some small-volume jobs while computers will be used for large-volume tasks.

Not every processing step is required for every piece of useful information produced. But if the data-processing operation is to produce information output, there must be an input of data. Let us now briefly look at the sources of these input facts.

SOURCES OF DATA

The input data used to produce management information originates from *internal* sources and from sources which are external to the business. *Internal sources* consist of individuals or departments located within the organization. These sources will furnish facts on a regular and planned basis to support managerial decisions if the potential user is aware that they are available and if he knows where they may be obtained. Once the need for the data is established (and the value of supplying it is deemed to be worth the cost), a systematic data-gathering procedure is designed to produce the facts. Not infrequently, a procedure for gathering data continues to be followed after the need for the data no longer exists.

In addition to what might be called "planned data gathering," data may also be received from internal sources on an unsolicited basis. Unsolicited facts may be quite important. For example, a company sales representative for the frozen-foods division of a large and diversified organization may learn that one

FIGURE 1-2 TOOLS AND TECHNIQUES FOR DATA PROCESSING

PROCESSING METHODS	STEPS IN THE DATA-PROCESSING OPERATION								
	Originating–Recording	Classifying	Sorting	Calculating	Summarization	Storing	Retrieving	Reproducing	Communicating
Manual methods	Human observation; handwritten records; pegboards	Hand posting; pegboards	Hand posting; pegboards; edge-notched cards	Human brain	Pegboards; Hand calculations	Paper in files, journals, ledgers, etc.	File clerk; bookkeeper	Clerical; carbon paper	Written reports; hand-carried messages
Manual with machine assistance	Typewriter, cash register	Cash register; bookkeeping machine	Mechanical collators	Adding machines; calculators; cash registers	Accounting machines, adding machines; cash registers	Motorized rotary files; microfilm		Xerox machines, duplicators; addressing machines	Documents prepared by machines; message conveyors
Electro-mechanical punched card methods	Prepunched cards; keypunched cards; mark-sensed cards	Determined by card field design; sorter; collator	Card sorter	Accounting machines (tabulators) calculating punch		Trays of cards	Manual tray movement	Reproducing punch	Printed documents
Electronic methods	Magnetic tape encoder; magnetic and optical character readers; card and tape punches; on-line terminals	Determined by systems design; computer	Offline card sorter; computer sorting	Computer		Magnetizable media and devices; punched media; computer	Online inquiry with direct access devices; manual movement of storage media to computer	Multiple copies from printers	Online data transmission; printed output; visual display; voice output

of his customers has under development an improved type of valve that may have marketing implications for the valve division of his own firm. Such information, if transmitted to the valve division, might be of great value. The movement of unsolicited facts to interested parties is dependent upon the possessor's willingness to transmit them and upon his knowledge of who the potential users are.

External sources are the generators and distributors of data located outside the organization. These sources include such categories as customers, suppliers, competitors, business publications, industry associations, and government agencies. Such sources provide the organization with environmental and/or competitive data. Government agencies, for example, furnish businesses with a wealth of environmental statistics—such as per-capita income, total consumer expenditures, and population-growth estimates—which are valuable for planning purposes. Industry associations and publications furnish data on competitive performance of products and companies. Industry statistics, combined with internal data, can assist in sales planning and in financial control.

NEED FOR INFORMATION

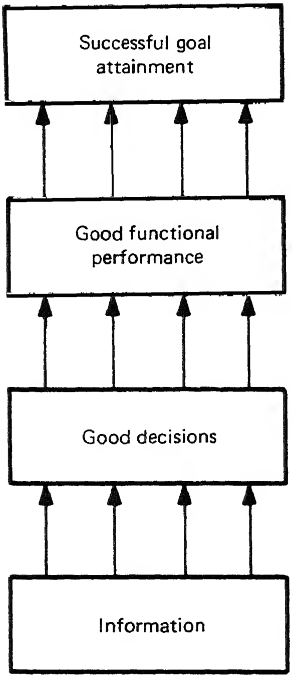
All managers must perform certain basic management functions in order to achieve company goals. The objectives pursued differ, of course, but the basic functions or activities are common to all. In other words, the activities of *planning, organizing, staffing,* and *controlling* are performed by all managers.[6]

The success of any business is determined by how well its executives perform these activities. And how well these functions are carried out is dependent, in part, upon how well the infomation needs of managers are being met.[7] Why is this? It is because each function involves decision making, and decision making must be supported by information which is accurate, timely, complete, concise, and relevant. If a manager's information does not possess these characteristics, the quality of the decisions which he makes will probably suffer and the business (at best) will not achieve the success it might otherwise have had. When viewed in this light, it is evident that information is a competitive tool. In summary, as shown in Figure 1-3, quality information in the hands of those who can effectively use it will support good decisions; good decisions will lead to effective performance of managerial functions; and effective functional

[6] We shall examine these functions more closely in Chap. 3.

[7] It is necessary to add that the manager must have the ability to effectively use the information which he receives. If he can't use it, either the information in its present form is wrong for the manager or the manager will have to be trained to use it properly. Merely providing a manager with "needed" information is no guarantee that it will be (or can be) effectively used.

FIGURE 1-3



performance will lead to successful attainment of organizational goals. Thus, as Sisson and Canning have observed, "information is the cement that holds together any organization."[8]

The *demand for information*, like the sources of supply of data input, originates from both internal and external locations. As we have just seen, managers within the organization need information for the performance of managerial functions. Information is also required, however, to meet demands originating from the environment in which the business operates. Reports of various kinds are required by government bodies;[9] dues reports are prepared for labor unions; annual and interim reports giving financial information are

[8] Roger L. Sisson and Richard G. Canning, *A Manager's Guide to Computer Processing,* John Wiley & Sons, Inc., New York, 1967, p. 1.

[9] A *Time* magazine article in 1964 announced that the U. S. Government required that the business community file 5,455 different reports during the year. In one extreme example, a farm products firm handled 173 different federal forms in a single year. Various reports were sent in at different intervals ranging from daily to annually. A final total of 37,683 reports, involving 48,285 man-hours of work, was submitted! In addition, businesses must also satisfy state- and local-government requirements.

expected by creditors, stockholders, and lending institutions; and market and product information may be desired by customers and suppliers of raw materials.

WHAT INFORMATION IS NEEDED?

What information does the manager need to manage effectively? A common need basic to all managers is an understanding of the purpose of the organization—i.e., its policies, its programs, its plans, and its goals. But beyond these basic informational requirements, the question of what information is needed can only be answered in broad general terms because individual managers differ in the ways in which they view information, in their analytical approaches in using it, and in their conceptual organization of relevant facts. An additional factor which complicates the subject of the information needed by managers is that of the organizational level of the managerial job. Managers at the lower operating levels need information to help them make the day-to-day operating decisions. At the top levels, however, information is needed to support long-range planning and policy decisions. In short, the types of decisions vary, and the information needs also vary. Thus, as Dr. Eugene Kozik, a General Electric planner, writes:[10]

> *We do not believe it is possible to design an information system on the basis of even the most exhaustive task analysis of the managerial jobs involved with any reasonable expectation that the system design will be uniformly suitable or desirable for all managers associated with the complex.*

The specific information needed by a particular manager includes everything that manager must have (1) to establish, evaluate, and adjust goals; (2) to develop plans and standards and to initiate action; (3) to measure actual performance and take appropriate action when performance varies from the standard; and (4) to assess achievements.

To carry the generalization of the preceding paragraph a step further, a manager should perform the following analysis to acquire the information he needs:

1 He should identify those factors which are critical to the success of his contribution to the organization's goals.
2 He should determine how these critical factors can be measured.
3 He should determine, for each critical factor, what quantifiable measurement constitutes success.

[0]Eugene Kozik, "Computer Augmentation of Managerial Reasoning," *Management Accounting,* vol. 48, p. 40, December, 1966.

4 He should take steps to acquire information that will be needed to insure achievement of "success measurements."

By following this general procedure, the manager will have the quality information which *he* needs to manage effectively.

DESIRED PROPERTIES OF MANAGEMENT INFORMATION

Output reports, taken by themselves, generally have little or no value to an organization unless they can be used to make decisions which lead to profitable business actions.[11] Information is a business resource, and like any other business resource it is not free. It is therefore necessary that the cost of acquiring the resource be compared with the value to be obtained from its availability. Just as it would be economically foolish for an organization to spend $100 to mine $75 worth of coal, so, too, would it be unsound to produce information costing $100 if this information did not lead to actions which yielded a net return. In other words, information should be prepared if its cost is less than the additional revenues produced or if it serves to reduce other expenses by a more than proportionate amount. In some cases the actual costs of preparing information can be compared with the *tangible* economic benefits obtained from its use. Frequently, however, the cost of producing information with characteristics generally considered to be desirable must be compared with benefits of an *intangible* nature. For example, whether or not revenue will be raised enough to justify additional costs which are frequently incurred to give managers more accurate, more timely, and more complete information with which to make operating and control decisions is something which must be considered by information-system designers.

The overview of information economics just presented should be kept in mind as we look at the desirability of information which possesses the characteristics of *accuracy, timeliness, completeness, conciseness,* and *relevancy*. Up to a certain point, information which possesses these properties may be expected to be more valuable than information lacking one or more of these characteristics.

ACCURACY Accuracy may be defined as the ratio of correct information to the total amount of information produced over a period of time. If, for example, 1,000 items of information are produced and 950 of these items give a correct report of the actual situation, then the level of accuracy is 0.95. Whether or not this level is high enough depends upon the information being produced. Fifty

[11] Reports required by government agencies are often costly to prepare and *may not* result in decisions which lead to profitable business actions. In such situations, however, the stalwart civil servant may be counted on to specify a penalty for not producing the information which will exceed the cost of report preparation.

incorrect bank balances in a mailing of 1,000 bank statements would hardly be acceptable to depositors or to the bank. On the other hand, if physical inventory records kept on large quantities of inexpensive parts achieve an accuracy level of 0.95, this might be acceptable. In the case of bank statements, greater accuracy *must* be obtained; in the case of the parts inventory, greater accuracy *could* be obtained, but the additional value to managers of having more accurate inventory information might be less than the additional costs required.

Inaccuracies are the result of *human errors* and/or *machine malfunctions*. Human error (in system design, in machine operation, in the preparation of input data, and in other ways) is the primary cause of inaccuracy. Computer equipment malfunctions occur only infrequently, and the machine failures which do appear are usually traceable to input/output devices. However, programmed error checks and built-in error-detecting features can often discover input/output malfunctions. An important benefit of well-designed computer information systems is their ability to provide much greater accuracy than the manual or electromechanical systems which they replace.

TIMELINESS Timeliness is another important information characteristic. It is of little consolation to a manager to know that information which arrived too late to be of use was accurate. Accuracy alone is not enough. An interesting fact is that in the past a trade-off between timeliness and accuracy was often required—i.e., greater accuracy might require more input data control points which could slow down the processing speed and therefore reduce the timeliness of the output information. Computer usage, however, reduces the significance of this conflict between accuracy and processing speed.

How fast must be the *response time* of the information system? Unfortunately, it is once again impossible to give an answer which will satisfy all situations. In the case of *regular reports*, an immediate response time following each relevant business transaction would involve a steady outpouring of documents, each of which would cover a very brief time interval. The result might well be a costly avalanche of paper. Report contents could not possibly be assimilated by the manager; and even if they could be, the time period involved would be too short to reveal meaningful trends, although superficial events could be blown up out of proportion to their importance. Thus, in the case of periodic reports, a compromise is often required. The response interval should be short enough so that the information does not lose its freshness and value and so that fewer expensive data-storage devices will be needed. On the other hand, the response interval should be long enough to reduce report volume (and associated costs) and reveal important trends which signal the need for action.

The most appropriate information interval is therefore a matter which must be determined by each organization. It should also be noted that once the cutoff date for the report period has arrived, further compromise is usually required.

Generally speaking, the shorter the delay in getting the information into the hands of the manager, the higher will be the costs involved.

In the next chapter we shall look at new computer-based information systems which provide quick-response times to managers. Systems have been developed which give access to records within a fraction of a second after an inquiry has been made. How current this information is depends upon the degree of quickness in updating the records. In some quick-response installations, the information may be updated periodically—e.g., daily or weekly—while in others it may be updated immediately after the completion of a transaction.

COMPLETENESS Most managers faced with a decision to make have been frustrated at some time by having supporting information which is accurate, timely—and *incomplete*. A report is complete if it gives the manager all the information he needs to make the decision. Admittedly, this is a rare document. But more complete information can often be provided through the design of systems which do a better job of integrating and consolidating available facts. A dramatic historical example of the consequences of failure to consolidate related pieces of information occurred at Pearl Harbor in 1941. Historians tell us that data available, in bits and pieces and at scattered points, if integrated, would have signaled the danger of a Japanese attack. Better integration of the facts available at scattered points in a business, for the purpose of furnishing managers with more complete information is a goal of information-systems designers. We shall look at the emphasis now being placed on these *broader systems* in the next chapter.

CONCISENESS As we have just seen, information completeness is a desirable characteristic. Many systems have been designed on the assumption that lack of completeness is the most critical deficiency of managerial information. Too often in the past, though, the solution has been to employ an ineffective shotgun approach, peppering the manager with more infomation than can possibly be used. Important information, along with relatively useless data, is buried in stacks of detailed and unrefined reports. The manager (if he uses the reports at all) is then faced with the problem of extracting those items of information which he needs. Concise information which summarizes (perhaps through the use of tables and charts) the relevant data and which points out areas of exception to normal or planned activities is what is often needed by—but less often supplied to—today's managers.

RELEVANCY Relevant information is "need-to-know" information which leads to action. "Nice-to-know" information placed in the hands of a manager who is not in a position to influence the events reported is not relevant information to that particular manager and thus it generally has no dollar value. Likewise, reports which were once valuable but which no longer lead to action

not relevant and should be discontinued. In other words, information is evant and is worth producing only if it will *"identify and support necessary tion by responsible individuals within the organization."*[12]

OLUTION OF INFORMATION PROCESSING

rlier in the chapter (in Figure 1-2) we classified data-processing methods into *nual, machine-assisted manual, electromechanical punched card,* and *elec-nic computer* categories. In the remaining pages of this chapter, let us use ese categories to briefly look at the evolution which has taken place in ormation-processing techniques and equipment from earliest times to about 60. In the following chapter we shall look at the revolutionary developments ich have occurred in the past decade.

ANUAL STAGE

r centuries, man lived on earth without keeping records. But as social ganizations such as tribes began to form, it became necessary for man to just. The complexities of tribal life required man to remember more details. ethods of counting, based on the biological fact that man has ten fingers, were us developed. However, the limited number of digits combined with the need remember more facts posed problems. For example, if a shepherd were nding a large tribal flock and if he had a short memory, how was he to keep ntrol of his inventory? Problems bring solutions, and the shepherd's solution ght have been to let a stone, a stick, a scratch on a rock, or a knot in a ing[13] represent each sheep in the flock.

As tribes grew into nations, trade and commerce developed. Stones and sticks, wever, were not satisfactory for early traders. In 3500 B.C., the ancient bylonian merchants were keeping records on clay tablets. At about the same ne (give or take a few centuries) the ancient Egyptians made a great provement in record keeping possible when they developed papyrus (the erunner of paper) and a sharp-pointed pen called a "calmus." An early anual calculating device was the abacus which, although over 2,000 years old, ay still be the most widely used calculator in the world. Manual record-keeping chniques continued to develop through the centuries with such innovations as

Richard Werling, "Action-Oriented Information Systems," *Datamation,* vol. 13, p. 59, June, 1967.

See the reading entitled "The Almost-Perfect Decision Device" at the end of this chapter for the amazing story of a society which employed a management information system built on knotted strings.

record audits (the Greeks), banking systems and budgets (the Romans), and double-entry bookkeeping (the Italians in Florence, Genoa, and Venice).

In the United States, in the twenty years following the Civil War, the main tools of data processing were pencils, rulers, worksheets (for classifying, calculating, and summarizing), journals (for storing), and ledgers (for storing and communicating). The data processors were clerks, and less than 1 percent of the processing work was machine aided. Such complete reliance upon manual methods resulted, of course, in information which was relatively inaccurate and often late. To the consternation of the Census Bureau, the 1880 census was not finished until it was almost time to begin the 1890 count!

MACHINE-ASSISTED MANUAL STAGE

The evolution of machine-assisted processing methods has gone through several phases. In the *first phase*, machines were produced which improved the performance of a *single* processing step. The typewriter, for example, is a recording aid which was introduced in the late 1880s. It improved legibility and doubled writing speeds. Also, in 1642 the first mechanical adding machine was developed by Blaise Pascal, a brilliant young Frenchman. About 30 years later Gottfried Leibniz, a German mathematician, improved upon Pascal's invention by producing a calculating machine which could add, subtract, multiply, divide, and extract roots. Although the principles of these early calculators were incorporated into other machines, it was not until well into the 1800s that the "grandfather" of present-day desk calculators was developed.

In the *second phase* of machine-assisted methods, equipment was invented which could *combine* certain processing steps in a single operation. Machines which could calculate and print the results were first produced in 1890. They combine calculating, summarizing, and recording steps and produce a printed tape record suitable for storing data. After World War I, accounting machines designed for special purposes (e.g., billing, retail sales, etc.) began to appear. These machines also combine steps and often contain several adding *registers* or *counters* to permit the accumulation of totals (calculation and summarization) for different classifications. For example, the supermarket cash register has separate registers to sort and total the day's sales of health items, hardware, meats, produce, and groceries.

ELECTROMECHANICAL PUNCHED CARD STAGE

The difficulties encountered in completing the 1880 census led to the development of a whole family of electromechanical devices to process punched cards. The history of punched card usage dates back to about the end of the American Revolution, when a French weaver named Jacquard used them to control his looms. However, the inventor of modern punched card techniques is

considered to be Dr. Herman Hollerith, who was hired by the Census Bureau to help find a solution to the census problem. In 1887, Hollerith developed his machine-readable card concept and designed a device known as the "Census Machine." Tabulating time with Hollerith's methods was only one-eighth of that previously required, so his techniques were adopted for use in the 1890 count. In the decade after 1880, population increased from 50 to 63 million. Yet the 1890 census was completed in less than three years. (By today's standards this is still intolerably slow, but think of the alternative then!) A company founded by Hollerith in 1896 later merged with others to become what is now International Business Machines Corporation (IBM).

Punched card equipment has been widely used in business since the 1930s. These machines are effective in performing many of the necessary individual processing steps—e.g., sorting and summarizing. But it is still necessary to have people handle trays of cards between steps. Separate machines must be fed, started, and stopped. This *limited intercommunication* between processing steps requiring manual intervention is a major disadvantage. The computer eliminates this disadvantage; no manual intervention between data input and information output is necessary. What sets the computer apart from other data-processing machines is the concept of storing, within the machine itself, alterable instructions which will direct the machine to automatically perform the necessary steps.

EARLY COMPUTER DEVELOPMENT

Charles Babbage, Lucasian Professor of Mathematics at Cambridge University in England, is generally regarded as the godfather of large digital computers. Babbage was an eccentric and colorful individual[14] who spent much of his life (and £17,000 of Her Majesty's funds) working in vain to build a machine he called the "Analytical Engine." Babbage's dream—to many others it was "Babbage's folly"—would have had punched card input, an arithmetic unit or "mill," a memory unit or "store," automatic printout, sequential program control, and 20-place accuracy. In short, Babbage had designed a prototype computer which was a hundred years ahead of its time. Following Babbage's death in 1871, little progress was made until 1937.

[14]Plagued by organ grinders and children who enjoyed annoying him, Babbage still found time to be a literary critic. In the poem entitled "The Vision of Sin," Tennyson wrote: "Every moment dies a man/ Every moment one is born." Babbage pointed out to the poet that since the world's population was increasing, it would be more accurate to have the verse read: "Every moment dies a man/ Every moment one and one-sixteenth is born."

The twenty years between 1937 and 1957 produced the following important events:[15]

1 The first large-scale *electromechanical* computer was built (1944).
2 The first *electronic* computer was completed (1946).
3 A basic philosophy of computer design was formulated (1946).
4 The first *stored program electronic* computer was finished (1949).
5 The first computer acquired for business data processing was installed (1954).
6 The competitive structure of an industry was established (1950–1957).

Beginning in 1937, Harvard professor Howard Aiken set out to build a computer which would combine established technology with the punched cards of Hollerith. With financial and technical backing from IBM, the project was completed in 1944. This machine—dubbed the "Mark I"—had mechanical arithmetic counters, and its operations were controlled by electromagnetic relays. Thus, it was not an electronic computer but rather an *electromechanical* one. The Mark I was, in many respects, the realization of Babbage's dream. It is now on display at Harvard.

The first electronic digital computer was built between 1939 and 1946 at the University of Pennsylvania's Moore School of Electrical Engineering by the team of John W. Mauchly and J. Presper Eckert, Jr. Vacuum tubes (19,000 of them!) were used in place of relays. The computer was called "ENIAC" and could do 300 multiplications per second (making it 300 times faster than any other device of the day).[16] Operating instructions for ENIAC were not stored internally; rather, they were fed through externally located plugboards and switches. In 1956, ENIAC was placed in the Smithsonian Institution.

In 1946 Dr. John von Neumann, a mathematical genius and member of the Institute for Advanced Study in Princeton, New Jersey, suggested in a paper that (1) *binary* numbering systems be used in building computers and (2) computer *instructions* as well as the data being manipulated could be stored internally. These suggestions became a basic part of the philosophy of computer design. The binary numbering system is represented by only two digits (0 and 1). Since electronic components are typically in one of two conditions (on or off,

[15] At the end of this chapter is an interesting article prepared by Dr. George Schussel, which describes this dramatic period in some detail. We shall merely point out the highlights in the remaining paragraphs.

[16] An Englishman named William Shanks spent twenty years of his life computing π to 707 decimal places. In 1949, ENIAC computed π to 2,000 places in just over seventy hours and showed that Shanks had made an error in the 528th decimal place. Having died much earlier, Shanks was spared the knowledge that he had been both slow and inaccurate.

magnetized or demagnetized, conducting or not conducting), the binary concept facilitated hardware design.

The design concepts came too late to be incorporated in ENIAC, but Mauchly, Eckert, and others at the University of Pennsylvania set out to build a machine with stored program capability. This machine—the EDVAC— was not completed until several years later. To the EDSAC, finished in 1949 at Cambridge University, must go the distinction of being the first *stored program electronic* computer.

One reason for the delay in EDVAC was that Eckert and Mauchly founded their own company in 1946 and began to work on the UNIVAC. In 1949, Remington Rand acquired the Eckert-Mauchly Computer Corporation, and in early 1951 the first UNIVAC-I became operational at the Census Bureau. In 1963, it too was retired to the Smithsonian Institution—an historical relic after just twelve years! The first computer acquired for *business data-processing* purposes was another UNIVAC-I which was installed in 1954 at General Electric's Appliance Park in Louisville, Kentucky.

Between 1950 and 1955, Remington Rand (now Sperry Rand Corporation) was the undisputed leader in the fledgling computer industry. There was initial reluctance on the part of IBM to enter the computer field, but the loss of Census Bureau business changed this attitude. Between 1954 and 1956, IBM recovered rapidly to produce new commercial computers. The IBM 650 gave that firm the leadership in computer production in 1955, and this leadership continues today with IBM having approximately 70 percent of the domestic computer market.

In the period from 1954 to 1960, many businesses acquired computers for data-processing purposes even though these *first-generation* machines had been designed for scientific uses. In the design of early equipment, emphasis was placed on computational capability with little attention being given to the input/output capacity of the machines. But since business data processing generally involves large volumes of record input and output with relatively little computation per record, the equipment available for data processing left something to be desired. Nevertheless, the early uses of computers left even more to be desired. Managers generally considered the computer to be an accounting tool, and the first applications were designed to process routine tasks such as payrolls and customer billing. Unfortunately, in most cases little or no attempt was made to modify and redesign existing accounting procedures in order to produce more effective managerial information. The potential of the computer was consistently underestimated; more than a few were acquired for no other reason than "prestige."

But we should not judge the early users of electronic data processing too harshly. They were pioneering in the use of a new tool not designed specifically for their needs; they had to staff their computer installations with a new breed of workers; and they initially had to cope with the necessity of preparing

programs in a tedious machine language until improvements in programming methods could be developed to speed up the coding process. In spite of these obstacles, the computer was found to be a fast, accurate, and untiring processor of mountains of paper.

The computers of the *second generation* were introduced around 1960 and were made smaller, faster, and with greater computing capacity through such improvements as the use of small, magnetizable rings or cores for internal storage of data and instructions. The vacuum tube, with its heat, bulk, and relatively short life, gave way to compact *solid state* components such as diodes and transistors. Unlike earlier computers, some second-generation machines were designed from the beginning with business-processing requirements in mind. In the next chapter we shall look more closely at second- and third-generation computer technology and at the information-processing revolution which businesses are now experiencing.

DISCUSSION QUESTIONS

1 (a) What is management information?
   (b) What is the difference between data and information?
2 (a) Identify and explain the basic steps of data processing.
   (b) What processing methods may be used to perform these steps?
3 (a) Why do managers need information?
   (b) How can quality information contribute to organizational goal attainment?
4 "Information is a competitive tool." Explain this sentence.
5 Why is it possible to state in only general terms what information a particular manager will need to manage effectively?
6 Identify and explain the desired properties of management information.
7 Identify and describe the role played by each of the following individuals in the evolution of data processing: (*a*) Herman Hollerith, (*b*) Charles Babbage, (*c*) Howard Aiken, (*d*) John W. Mauchly and J. Presper Eckert, Jr., (*e*) John von Neumann.
8 Describe the important contributions of the following computers: (*a*) ENIAC, (*b*) Mark I, (*c*) UNIVAC-I, (*d*) EDVAC, (*e*) Analytical Engine.
9 What were some of the differences between first- and second-generation computers?

CHAPTER ONE READINGS

INTRODUCTION TO READINGS 1 THROUGH 4

1 Five assumptions commonly made by designers of management information systems are identified by Professor Ackoff. He points out that these assumptions (*a*) are usually false, and (*b*) have led to major deficiencies in many designed systems. After examining each of the five assumptions, the article outlines a design procedure which avoids these assumptions.

2 Gerald E. Nichols presents in this reading a detailed discussion of the elements involved in the generation and evaluation of management information. Among the topics considered are the information-generating system, the attributes of information, and the value of information.

3 The ancient Inca civilization which flourished in the Andes Mountains of South America employed a surprisingly modern management information system—an amazing system built on knotted strings! This article explains the Inca's system, tells what made it work, and reveals the fatal flaw that spelled its overnight doom.

4 In this reading, Dr. George Schussel describes the following early computer developments in detail: (*a*) the development of the Mark I, (*b*) the construction of the ENIAC, (*c*) the reasons for IBM's initial reluctance to enter the computer market, and (*d*) the establishment of the competitive structure of the computer industry.

READING 1 MANAGEMENT MISINFORMATION SYSTEMS*

RUSSELL L. ACKOFF

The growing preoccupation of operations researchers and management scientists with Management Information Systems (MIS's) is apparent. In fact, for some the design of such systems has almost become synonymous with operations research or management science. Enthusiasm for such systems is understandable: it involves the researcher in a romantic relationship with the most glamorous

*Reprinted from *Management Science* (Application Series), vol. 14, no. 4, pp. B-147—B-156, December, 1967. Reprinted by permission from The Institute of Management Sciences, Pleasantville, N.Y. Russell L. Ackoff is a Professor at the Wharton School of the University of Pennsylvania.

instrument of our time, the computer. Such enthusiasm is understandable but, nevertheless, some of the excesses to which it has led are not excusable.

Contrary to the impression produced by the growing literature, few computerized management information systems have been put into operation. Of those I've seen that have been implemented, most have not matched expectations and some have been outright failures. I believe that these near- and far-misses could have been avoided if certain false (and usually implicit) assumptions on which many such systems have been erected had not been made.

There seem to be five common and erroneous assumptions underlying the design of most MIS's, each of which I will consider. After doing so I will outline an MIS design procedure which avoids these assumptions.

GIVE THEM MORE

Most MIS's are designed on the assumption that the critical deficiency under which most managers operate is the *lack of relevant information*. I do not deny that most managers lack a good deal of information that they should have, but I do deny that this is the most important informational deficiency from which they suffer. It seems to me that they suffer more from an *over abundance of irrelevant information.*

This is not a play on words. The consequences of changing the emphasis of an MIS from supplying relevant information to eliminating irrelevant information is considerable. If one is preoccupied with supplying relevant information, attention is almost exclusively give to the generation, storage, and retrieval of information: hence emphasis is placed on constructing data banks, coding, indexing, updating files, access languages, and so on. The ideal which has emerged from this orientation is an infinite pool of data into which a manager can reach to pull out any information he wants. If, on the other hand, one sees the manager's information problem primarily, but not exclusively, as one that arises out of an overabundance of irrelevant information, most of which was not asked for. then the two most important functions of an information system become *filtration* (or evaluation) and *condensation*. The literature on MIS's seldom refers to these functions let alone considers how to carry them out.

My experience indicates that most managers receive much more data (if not information) than they can possibly absorb even if they spend all of their time trying to do so. Hence they already suffer from an information overload. They must spend a great deal of time separating the relevant from the irrelevant and searching for the kernels in the relevant documents. For example, I have found that I receive an average of forty-three hours of unsolicited reading material each week. The solicited material is usually half again this amount.

I have seen a daily stock status report that consists of approximately six hundred pages of computer print-out. The report is circulated daily across managers' desks. I've also seen requests for major capital expenditures that come

in book size, several of which are distributed to managers each week. It is not uncommon for many managers to receive an average of one journal a day or more. One could go on and on.

Unless the information overload to which managers are subjected is reduced, any additional information made available by an MIS cannot be expected to be used effectively.

Even relevant documents have too much redundancy. Most documents can be considerably condensed without loss of content. My point here is best made, perhaps, by describing an experiment that a few of my colleagues and I conducted on the OR literature several years ago. By using a panel of well-known experts we identified four OR articles that all members of the panel considered to be "above average," and four articles that were considered to be "below average." The authors of the eight articles were asked to prepare "objective" examinations (duration thirty minutes) plus answers for graduate students who were assigned the articles for reading. (The authors were not informed about the experiment.) Then several experienced writers were asked to reduce each article to 2/3 and 1/3 of its original length only by eliminating words. They also prepared a brief abstract of each article. Those who did the condensing did not see the examinations to be given to the students.

A group of graduate students who had not previously read the articles were then selected. Each one was given four articles randomly selected, each of which was in one of its four versions: 100%, 67%, 33%, or abstract. Each version of each article was read by two students. All were given the same examinations. The average scores on the examinations were then compared.

For the above-average articles there was no significant difference between average test scores for the 100%, 67%, and 33% versions, but there was a significant decrease in average test scores for those who had read only the abstract. For the below-average articles there was no difference in average test scores among those who had read the 100%, 67%, and 33% versions, but there was a significant *increase* in average test scores of those who had read only the abstract.

The sample used was obviously too small for general conclusions but the results strongly indicate the extent to which even good writing can be condensed without loss of information. I refrain from drawing the obvious conclusion about bad writing.

It seems clear that condensation as well as filtration, performed mechanically or otherwise, should be an essential part of an MIS, and that such a system should be capable of handling much, if not all, of the unsolicited as well as solicited information that a manager receives.

THE MANAGER NEEDS THE INFORMATION THAT HE WANTS

Most MIS designers "determine" what information is needed by asking managers

what information they would like to have. This is based on the assumption that managers know what information they need and want it.

For a manager to know what information he needs he must be aware of each type of decision he should make (as well as does) and he must have an adequate model of each. These conditions are seldom satisfied. Most managers have some conception of at least some of the types of decisions they must make. Their conceptions, however, are likely to be deficient in a very critical way, a way that follows from an important principle of scientific economy: the less we understand a phenomenon, the more variables we require to explain it. Hence, the manager who does not understand the phenomenon he controls plays it "safe" and, with respect to information, wants "everything." The MIS designer, who has even less understanding of the relevant phenomenon than the manager, tries to provide even more than everything. He thereby increases what is already an overload of irrelevant information.

For example, market researchers in a major oil company once asked their marketing managers what variables they thought were relevant in estimating the sales volume of future service stations. Almost seventy variables were identified. The market researchers then added about half again this many variables and performed a large multiple linear regression analysis of sales of existing stations against these variables and found about thirty-five to be statistically significant. A forecasting equation was based on this analysis. An OR team subsequently constructed a model based on only one of these variables, traffic flow, which predicted sales better than the thirty-five variable regression equation. The team went on to *explain* sales at service stations in terms of the customers' perception of the amount of time lost by stopping for service. The relevance of all but a few of the variables used by the market researchers could be explained by their effect on such perception.

The moral is simple: one cannot specify what information is required for decision making until an explanatory model of the decison process and the system involved has been constructed and tested. Information systems are subsystems of control systems. They cannot be designed adequately without taking control into account. Furthermore, whatever else regression analyses can yield, they cannot yield understanding and explanation of phenomena. They describe and, at best, predict.

GIVE A MANAGER THE INFORMATION HE NEEDS AND HIS DECISON MAKING WILL IMPROVE

It is frequently assumed that if a manager is provided with the information he needs, he will then have no problem in using it effectively. The history of OR stands to the contrary. For example, give most managers an initial tableau of a typical "real" mathematical programming, sequencing, or network problem and see how close they come to an optimal solution. If their experience and

judgment have any value they may not do badly, but they will seldom do very well. In most management problems there are too many possibilities to expect experience, judgment, or intuition to provide good guesses, even with perfect information.

Furthermore, when several probabilities are involved in a problem the unguided mind of even a manager has difficulty in aggregating them in a valid way. We all know many simple problems in probability in which untutored intuition usually does very badly (e.g., What are the correct odds that 2 of 25 people selected at random will have their birthdays on the same day of the year?). For example, very few of the results obtained by queuing theory, when arrivals and service are probabilistic, are obvious to managers; nor are the results of risk analysis where the managers' own subjective estimates of probabilities are used.

The moral: it is necessary to determine how well managers can use needed information. When because of the complexity of the decision process, they can't use it well, they should be provided with either decision rules or performance feed-back so that they can identify and learn from their mistakes. More on this point later.

MORE COMMUNICATION MEANS BETTER PERFORMANCE

One characteristic of most MIS's which I have seen is that they provide managers with better current information about what other managers and their departments and divisions are doing. Underlying this provision is the belief that better interdepartmental communication enables managers to coordinate their decisions more effectively and hence improves the organization's overall performance. Not only is this not necessarily so, but it seldom is so. One would hardly expect two competing companies to become more cooperative because the information each acquires about the other is improved. This analogy is not as far fetched as one might first suppose. For example, consider the following very much simplified version of a situation I once ran into. The simplification of the case does not affect any of its essential characteristics.

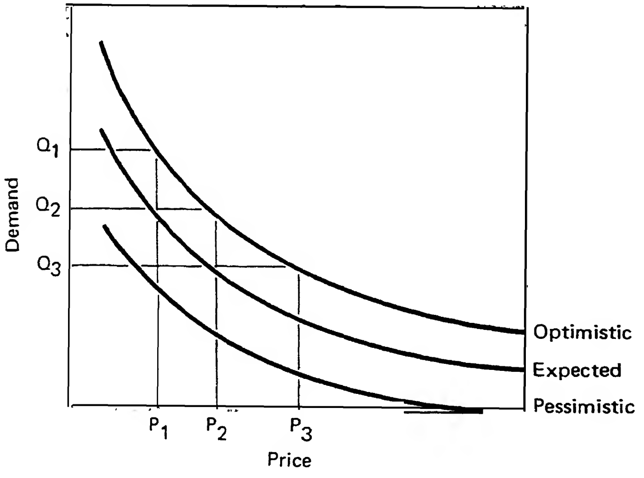
A department store has two "line" operations: buying and selling. Each function is performed by a separate department. The Purchasing Department primarily controls one variable: how much of each item is bought. The Merchandising Department controls the price at which it is sold. Typically, the measure of performance applied to the Purchasing Department was the turnover rate of inventory. The measure applied to the Merchandising Department was gross sales; this department sought to maximize the number of items sold times their price.

Now by examining a single item let us consider what happens in this system. The merchandising manager, using his knowledge of competition and consumption, set a price which he judged would maximize gross sales. In doing so he

utilized price-demand curves for each type of item. For each price the curves show the expected sales and values on an upper and lower confidence band as well. (See Figure 1.) When instructing the Purchasing Department how many items to make available, the merchandising manager quite naturally used the value on the upper confidence curve. This minimized the chances of his running short which, if it occurred, would hurt his performance. It also maximized the chances of being over-stocked but this was not his concern, only the purchasing manager's. Say, therefore, that the merchandising manager initially selected price P_1 and requested that amount Q_1 be made available by the Purchasing Department.

In this company the purchasing manager also had access to the price-demand curves. He knew the merchandising manager always ordered optimistically. Therefore, using the same curve he read over from Q_1 to the upper limit and down to the expected value from which he obtained Q_2, the quantity he actually intended to make available. He did not intend to pay for the merchandising manager's optimism. If merchandising ran out of stock, it was not his worry. Now the merchandising manager was informed about what the purchasing manager had done so he adjusted his price to P_2. The purchasing manager in turn was told that the merchandising manager had made this readjustment so he planned to make only Q_3 available. If this process—made possible only by perfect communication between departments—had been allowed to continue, nothing would have been bought and nothing would have been sold. This outcome was avoided by prohibiting communication between departments and forcing each to guess what the other was doing.

FIGURE 1 PRICE-DEMAND CURVE



I have obviously caricatured the situation in order to make the point clear: when organizational units have inappropriate measures of performance which put them in conflict with each other, as is often the case, communication between them may hurt organizational performance, not help it. Organizational structure and performance measurement must be taken into account before opening the flood gates and permitting the free flow of information between parts of the organization. (A more rigorous discussion of organizational structure and the relationship of communication to it can be found in "Systems Theory from an Operations Research Point of View.")[1]

A MANAGER DOES NOT HAVE TO UNDERSTAND HOW AN INFORMATION SYSTEM WORKS, ONLY HOW TO USE IT

Most MIS designers seek to make their systems as innocuous and unobtrusive as possible to managers lest they become frightened. The designers try to provide managers with very easy access to the system and assure them that they need to know nothing more about it. The designers usually succeed in keeping managers ignorant in this regard. This leaves managers unable to evaluate the MIS as a whole. It often makes them afraid to even try to do so lest they display their ignorance publicly. In failing to evaluate their MIS, managers delegate much of the control of the organization to the system's designers and operators who may have many virtues, but managerial competence is seldom among them.

Let me cite a case in point. A Chairman of a Board of a medium-sized company asked for help on the following problem. One of his larger (decentralized) divisions had installed a computerized production-inventory control and manufacturing-manager information system about a year earlier. It had acquired about $2,000,000 worth of equipment to do so. The Board Chairman had just received a request from the Division for permission to replace the original equipment with newly announced equipment which would cost several times the original amount. An extensive "justification" for doing so was provided with the request. The Chairman wanted to know whether the request was really justified. He admitted to complete incompetence in this connection.

A meeting was arranged at the Division at which I was subjected to an extended and detailed briefing. The system was large but relatively simple. At the heart of it was a reorder point for each item and a maximum allowable stock level. Reorder quantities took lead-time as well as the allowable maximum into account. The computer kept track of stock, ordered items when required and

[1] S. S. Sengupta and R. L. Ackoff, "Systems Theory from an Operations Research Point of View," *IEEE Transactions on Systems Science and Cybernetics,* vol. 1, November, 1965, pp. 9-13.

generated numerous reports on both the state of the system it controlled and its own "actions."

When the briefing was over I was asked if I had any questions. I did. First I asked if, when the system had been installed, there had been many parts whose stock level exceeded the maximum amount possible under the new system. I was told there were many. I asked for a list of about thirty and for some graph paper. Both were provided. With the help of the system designer and volumes of old daily reports I began to plot the stock level of the first listed item over time. When this item reached the maximum "allowable" stock level it had been reordered. The system designer was surprised and said that by sheer "luck" I had found one of the few errors made by the system. Continued plotting showed that because of repeated premature reordering the item had never gone much below the maximum stock level. Clearly the program was confusing the maximum allowable stock level and the reorder point. This turned out to be the case in more than half of the items on the list.

Next I asked if they had many paired parts, ones that were only used with each other; for example, matched nuts and bolts. They had many. A list was produced and we beaan checking the previous day's withdrawals. For more than half of the pairs the differences in the numbers reordered as withdrawn were verv large. No explanation was provided.

Before the day was out it was possible to show by some quick and dirty calculations that the new computerized system was costing the company almost $150,000 per month more than the hand system which it had replaced, most of this in excess inventories.

The recommendation was that the system be redesigned as quickly as possible and that the new equipment not be authorized for the time being.

The questions asked of the system had been obvious and simple ones. Managers should have been able to ask them but—and this is the point—they felt themselves incompetent to do so. They would not have allowed a handoperated system to get so far out of their control.

No MIS should ever be installed unless the managers for whom it is intended are trained to evaluate and hence control it rather than be controlled by it.

A SUGGESTED PROCEDURE FOR DESIGNING AN MIS

The erroneous assumptions I have tried to reveal in the preceding discussion can, I believe, be avoided by an appropriate design procedure. One is briefly outlined here.

1 ANALYSIS OF THE DECISION SYSTEM Each (or at least each important) type of managerial decision required by the organization under study should be identified and the relationships between them should be determined and flow-charted. Note that this is *not* necessarily the same thing as determining what decisions *are* made. For example, in one company I found that

make-or-buy decisions concerning parts were made only at the time when a part was introduced into stock and was never subsequently reviewed. For some items this decision had gone unreviewed for as many as twenty years. Obviously, such decisions should be made more often; in some cases, every time an order is placed in order to take account of current shop loading, underused shifts, delivery times from suppliers, and so on.

Decision-flow analyses are usually self-adjusting. They often reveal important decisions that are being made by default (e.g., the make-buy decision referred to above); and they disclose interdependent decisions that are being made independently. Decision -flow charts frequently suggest changes in managerial responsibility, organizational structure, and measure of performance which can correct the types of deficiencies cited.

Decision analyses can be conducted with varying degrees of detail, that is, they may be anywhere from coarse to fine grained. How much detail one should become involved with depends on the amount of time and resources that are available for the analysis. Although practical considerations frequently restrict initial analyses to a particular organizational function, it is preferable to perform a coarse analysis of all of an organization's managerial functions rather than a fine analysis of one or a subset of functions. It is easier to introduce finer information into an integrated information system than it is to combine fine subsystems into one integrated system.

2 AN ANALYSIS OF INFORMATION REQUIREMENTS Managerial decisions can be classified into three types:

(a) Decisons for which adequate models are available or can be constructed and from which optimal (or near optimal) solutions can be derived. In such cases the decision process itself should be incorporated into the information system thereby converting it (at least partially) to a control system. A decision model identifies what information is required and hence what information is relevant.

(b) Decisions for which adequate models can be constructed but from which optimal solutions cannot be extracted. Here some kind of heuristic or search procedure should be provided even if it consists of no more than computerized trial and error. A simulation of the model will, as a minimum, permit comparison of proposed alternative solutions. Here too the model specifies what information is required.

(c) Decisions for which adequate models cannot be constructed. Research is required here to determine what information is relevant. If decision making cannot be delayed for the completion of such research or the decision's effect is not large enough to justify the cost of research, then judgment must be used to "guess" what information is relevant. It may be possible to make explicit the implicit model used by the decision maker and treat it as a model of type (b).

In each of these three types of situation it is necessary to provide feedback by

comparing actual decision outcomes with those predicted by the model or decision maker. Each decision that is made, along with its predicted outcome, should be an essential input to a management control system. I shall return to this point below.

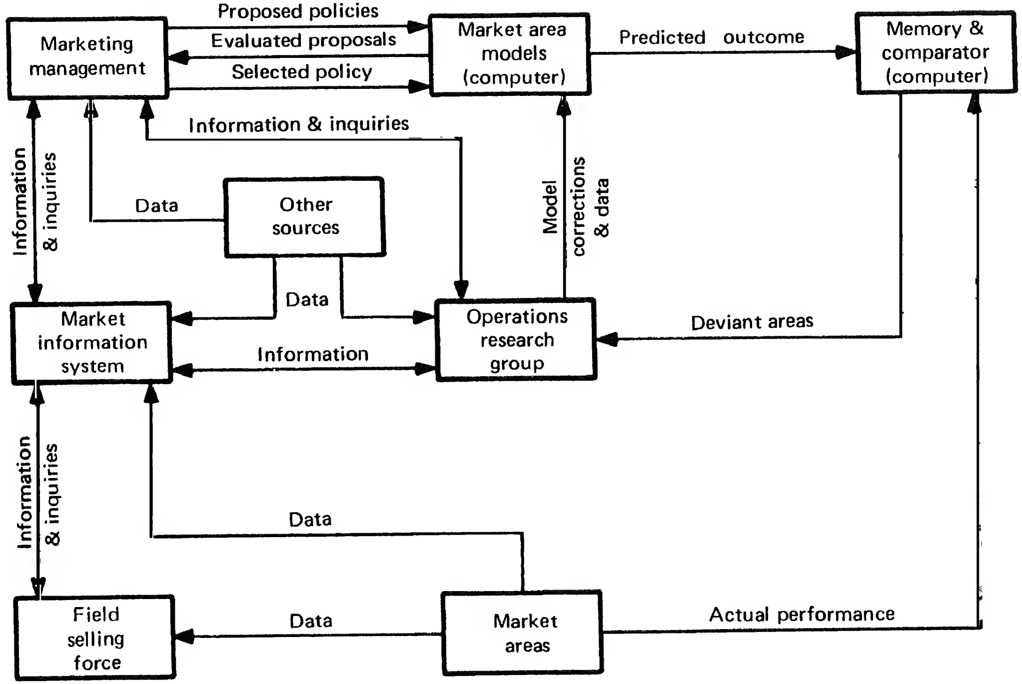
3 AGGREGATION OF DECISIONS Decisions with the same or largely overlapping informational requirements should be grouped together as a single managers' task. This will reduce the information a manager requires to do his job and is likely to increase his understanding of it. This may require a reorganization of the system. Even if such a reorganization cannot be implemented completely what can be done is likely to improve performance significantly and reduce the information loaded on managers.

4 DESIGN OF INFORMATION PROCESSING Now the procedure for collecting, storing, retrieving, and treating information can be designed. Since there is a voluminous literature on this subject I shall leave it at this except for one point. Such a system must not only be able to answer questions addressed to it; it should also be able to answer questions that have not been asked by reporting any deviations from expectations. An extensive exception-reporting system is required.

5 DESIGN OF CONTROL OF THE CONTROL SYSTEM It must be assumed that the system that is being designed will be deficient in many and significant ways. Therefore it is necessary to identify the ways in which it may be deficient, to design procedures for detecting its deficiencies, and for correcting the system so as to remove or reduce them. Hence the system should be designed to be flexible and adaptive. This is little more than a platitude, but it has a not-so-obvious implication. No completely computerized system can be as flexible and adaptive as can a man-machine system. This is illustrated by a concluding example ot a system that is being developed and is partially in operation. (See Figure 2.)

The company involved has its market divided into approximately two hundred marketing areas. A model for each has been constructed as is "in" the computer. On the basis of competitive intelligence supplied to the service marketing manager by marketing researchers and information specialists he and his staff make policy decisions for each area each month. Their tentative decisions are fed into the computer which yields a forecast of expected performance. Changes are made until the expectations match what is desired. In this way they arrive at "final" decisions. At the end of the month the computer compares the actual performance of each area with what was predicted. If a deviation exceeds what could be expected by chance, the company's OR Group then seeks the reason for the deviation, performing as much research as is required to find it. If the cause is found to be permanent the computerized model is adjusted

FIGURE 2 SIMPLIFIED DIAGRAM OF A MARKET-AREA CONTROL SYSTEM



appropriately. The result is an adaptive man-machine system whose precision and generality is continuously increasing with use.

Finally it should be noted that in carrying out the design steps enumerated above, three groups should collaborate: information systems specialists, operations researchers, *and managers*. The participation of managers in the design of a system that is to serve them, assures their ability to evaluate its performance by comparing its output with what was predicted. Managers who are not willing to invest some of their time in this process are not likely to use a management control system well, and their system, in turn, is likely to abuse them.

READING 1 DISCUSSION QUESTIONS

1 Identify and discuss the five assumptions which have often produced "management misinformation systems."
2 Discuss the five steps in the suggested procedure for designing an MIS.

READING 2 ON THE NATURE OF MANAGEMENT INFORMATION*

GERALD E. NICHOLS

The primary purpose of a management information system is to expose significant relationships that will decrease uncertainty in organizational decision-making with a corresponding increase in the utilization of organization resources. Those concerned with achieving this goal need some criteria for guiding their efforts. The necessary considerations include a knowledge of the types and qualities of information needed throughout the organization, for the fate of the business is determined by the information supplied the decision-maker.

This paper attempts to give the reader some insights into the elements to be considered in judging information. Such knowledge should facilitate both the generation and use of business information.

CLASSIFICATION AND INFORMATION

Man is confronted with a wide and varied environment. To reduce the diversity of his environment to manageable order, man resorts to classification and to the

*Reprinted from *Management Accounting,* pp. 9-13ff, April, 1969. Reprinted by permission from the National Association of Accountants, 505 Park Avenue, New York. Professor Nichols teaches accounting and computer science courses at Michigan State University.

formation of general ideas about groups of things—that is, man simplifies to aid comprehension.

Information generation[1] requires four steps if it is to be useful beyond the moment of observation or useful to individuals and groups other than the observer. The steps involve:

1 Classification of data—the basic problem is relating observations to anticipated situations of all classes of economic decision-makers.
2 Establishment of procedures for recording data in a manner facilitating recall, yet sufficiently simplified to enable the operation to be routinized.
3 Summarization of data classified and recorded.
4 Specification of the collection procedure of the system.

Classification reduces the complexity of the material, provides a means of identification by grouping like things together, provides a record of experience, and orders and relates classes of events. Three major characteristics[2] of any classification system are that:

1 Classes must not overlap—they must be mutually exclusive.
2 The classification system must be exhaustive—each item to be classified must be placed in some distinct category.
3 The basis of classification must be significant (related to some specific goal) and in accordance with some predetermined pattern.

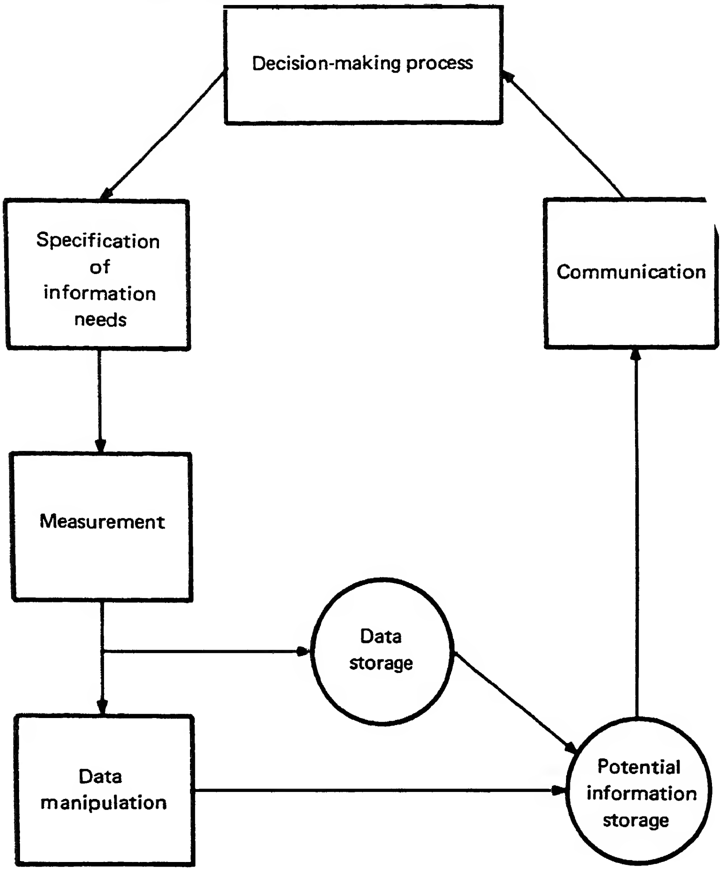
THE INFORMATION GENERATING SYSTEM

The general functions of information systems are to determine user needs, to select pertinent data from the infinite variety available from an organization's environments (internal and external), to create information by applying the appropriate tools to the data selected, and to communicate the generated information to the user. Such a system is depicted in Exhibit 1. This presentation uses the three levels of information postulated by Gregory and Van Horn[3] who state that:

> *Considered at the* syntactic *level, data consists of collections of symbols or characters arranged in some orderly way to serve as the vehicle for information. Information is the meaning derived from data and represents the* semantic *level—the relationship between a symbol and the actual object or*

[1] James W. Giese, *Classification of Economic Data in Accounting,* a dissertation, University of Illinois, 1962, p.122.
[2] *Ibid.,* p. 15.
[3] Robert H. Gregory and Richard L. Van Horn, *Automatic Data Processing Systems,* Wadsworth Publishing Company, Inc., Belmont, Calif., 1965, p. 54.

EXHIBIT 1 AN INFORMATION SYSTEM.



condition that is symbolized. The impact of the objects or conditions on the receiver represents the pragmatic *level of information.*

Thus "data" is used to refer to perceived and symbolized events (syntactic information); "potential information" refers to meaning derived from data (semantic information); and "information" refers to the impact upon the receiver (pragmatic information). Each of the functions depicted in Exhibit 1 will be discussed in detail.

SPECIFICATION OF INFORMATION NEEDS

The specification of needs is necessary since information has meaning only when associated with the decision to be made. This element also implicitly includes the

specification of the events to be observed and the time and place of observation.

The information that is generated and made available within the organization should be tailored to the task at hand. However, the concept of "tailoring" within the organization is much more comprehensive. "Tailoring" requires that the *decision-maker* and the information required by the decision be matched at each decision point within the organization.

The emphasis is upon supplying each decision point with enough information, of the right quality, when it is needed. This requires that the system be constantly updated. Not only must the information supplied the decision point be current but the skills, or knowledge level, of the decision-maker, *per se,* must also be kept current. That is, the information to be supplied the decision point must be tailored not only to the specific requirements of the decision to be made but also to the skills, attitudes, and capabilities of the decision-maker. The manager must be supplied with information he can comprehend and use effectively.

Ideally then, the information flowing to any given decision point would be adjusted when changes occurred in the capabilities of the decision-maker, or in the information available or pertinent to the decision; or if the manager responsible for a given decision were changed.

MEASUREMENT

As used here, measurement includes the observation and symbolization of the pertinent aspects of the above-specified events in one of the four possible measurement scales: nominal, ordinal, interval and ratio.

The nominal scale refers essentially to classification; whereas the ordinal scale requires that things or classes of things be ranked minimally as either "less than" or "greater than," but may include the assignment of numbers of symbols as a means of ranking multiple objects or classes. The objects ranked must be comparable in terms of some relationship.

The interval scale not only ranks objects or classes but also contains information on how large the interval is numerically. The rules of the real number system are applicable to an interval measure, but not all arithmetic operations can be applied because the interval scale has an arbitrary zero and thus many different scales can be applied to measure the same phenomenon. For example, temperature can be measured in either degrees centigrade or degrees Fahrenheit.

The ratio scale is an interval scale whose origin is absolute zero. All arithmetic operations are applicable to measurements derived using a ratio scale.

Note should be made of the fact that measurement, and thus, data, is concerned only with the *past,* since an event must have occurred before it can be measured.

DATA MANIPULATION

Management is concerned with the past, the present and the future. Since data is past oriented, manipulation is necessary to convert data into potential information relevant to the present and the future. In a sense, data may also be potential information, requiring only that it be communicated to management. Johnson, Kast, and Rosenzweig have stated that:

> *"The information-decision-system must be designed to garner pertinent facts and screen unwanted or unusual data. Screened data may become information for managerial decision-making. However, it is more likely that additional processing is necessary before meaningful information is available.*[4]

Time is an essential consideration in developing and presenting information. Therefore, manipulation is also concerned with the timeliness of data determination and presentation, and thus its conversion into potential information. Manipulation is definitely necessary for converting data to potential information concerning decisions affecting the future.

Actually, all decisions concern the future and are based on past experience. In the business organization records of past experience (data) usually require manipulation such as summarization to expose significant relationships that will reduce uncertainty in decision-making. Other common manipulations are the determination and extrapolation of trends, correlation analysis of organization data with economic indicators, simulations, or the assignment of probabilities to possible situation outcomes.

DATA AND POTENTIAL INFORMATION STORAGE

In this day of absentee ownership and the large organization, the decision-maker does not usually gather all of the information necessary for the decisions he makes. Potential information is generated throughout the organization which requires that some form of intermediary storage be used. Data covering long periods of time are necessary for some manipulations and decisions. Hence, data must be stored until needed. Data storage is also necessary where specialization within the information generating process is used.

It should be observed that data refers to measures of events concerned with the organization's internal and external environments, while "potential information" and "information" are internally oriented concepts. Data and potential information storage may involve such things as written documents, punched cards, or magnetic tapes, and a concomitant concern with the method and speed of retrieval.

[4] Richard A. Johnson, Fremont E. Kast, and James E. Rosenzweig, *The Theory and Management of Systems,* McGraw-Hill Book Company, Inc., New York, 1963, p. 181.

COMMUNICATION

Communication problems can be considered from three different levels—the technical, the semantic and the effectiveness levels. These considerations are comparable to those previously associated with information. However, only the effectiveness level will be considered here.

"Effectiveness" implies a relationship to purpose. The effectiveness of a communication refers to the changes it causes in the pursuit of a purpose. The effectiveness of a communication is determined by comparing the purposeful states of the decision-maker before and after receipt of the communication.

The communication[5] is considered to have been effective if it changes a purposeful state in one of three possible ways:

1 Informs—changes the probabilities of a choice
2 Instructs—changes the efficiencies of a course of action
3 Motivates—changes the values of the outcomes

Effective communication of information may result from proper sequencing, spacing, coloring, or things of like nature that affect or result in the reduction of uncertainty in the decision-maker. Thus, potential information must be effectively communicated and have news content pertinent to a given decision to be considered information. These considerations tie in with the concept of "tailoring" which stresses the importance of the decision-maker as well as the information supplied a decision point.

THE ATTRIBUTES OF INFORMATION

The management information system is, in general, concerned with information pertinent to the achievement of organization goals. Representations of an event require two basic types of information, quantitative and descriptive.

Quantitative information tells how much or how many; but the majority of the information will be descriptive and will serve to identify that which has been quantified. Business information specifically requires information regarding the five basic flows of economic systems—money, orders, materials, personnel, and capital equipment—in a time, or dynamic, context.

A partial list of desirable business information attributes are: relevance, availability, timeliness, objectivity, sensitivity, comparability, conciseness, completeness, quantifiability and quality. The meanings of most of these attributes are self-evident even though there may be some overlap in meanings.

Information *must* possess the first three attributes—relevance, availability, and timeliness—to have value, and thus to qualify as information. Objectivity,

[5] Russell L. Ackoff, "Towards a Behavioral Theory of Communication," *Management Services,* April 1958, p. 226.

sensitivity, comparability, conciseness, and completeness are desirable, but they are present and necessary only in varying degrees. These latter attributes of information are favorably influenced when the information is derived using higher levels of measurement scales, progressing up from the nominal to the ratio. That is to say, quantifiability is desirable.

The last attribute, quality, refers to the presence or absence of ambiguities in information. All information should possess "quality." Measures of quality are validity, accuracy, and precision. These measures of quality are especially important and applicable to quantified information, for quantified information creates the illusion of rightness. However, numbers are of course not sacred and are subject to ambiguities.

INFORMATION AND THE MANAGEMENT HIERARCHY

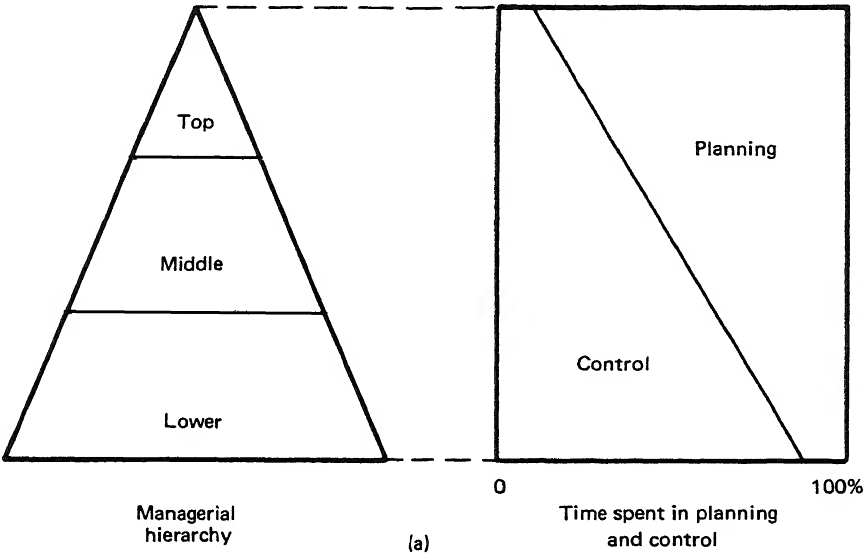
The amount, or quantity, of information to be provided each decision-maker is a function ot the state of arts and the individual decision-maker as determined by the application of the "tailoring" concept. The amount of information supplied management is also a function of the relative position of the manager in the managerial hierarchy and the environment with which the information is concerned—the internal environment of the organization and the environment in which the organization exists, its external environment. It is a well known generalization that internal information should be more and more summarized as the level of management for which the information is prepared increases in the hierarchical structures, with top management receiving the most summarized reports. This contention is based upon the fact that most internal data is control oriented and the lower echelons of management are the most control oriented; while top management is more planning oriented.

This situation is depicted in Exhibit 2a where management activity is bisected into planning and control. Exhibit 2a is to be interpreted broadly and is not intended to portray accurately the actual percentage of the time spent by the various levels of management in either planning or control. However, the representation is roughly correct according to an estimate by Terry.[6]

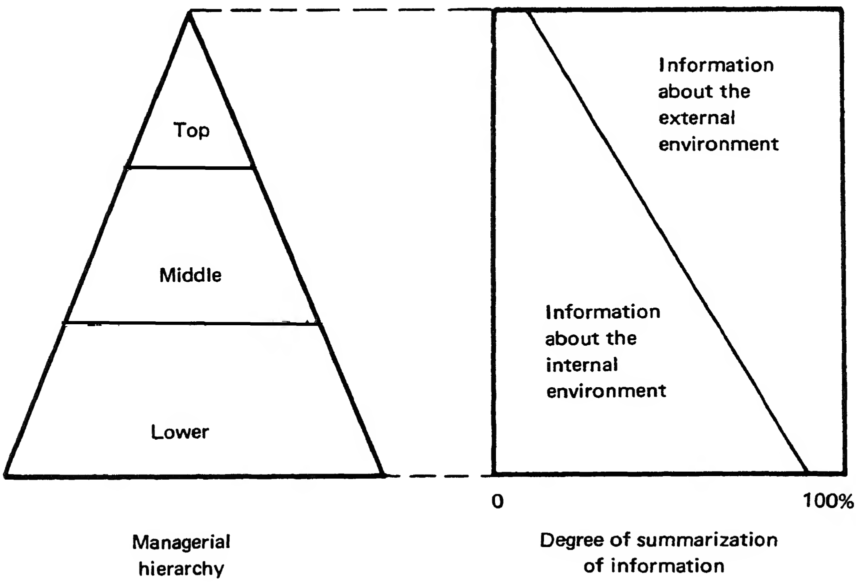
It seems just as plausible to generalize that information concerning the external environment of the organization should be summarized in a manner exactly opposite to that posited for information concerning the internal environment. This is to say that since the upper levels of management are more planning oriented and since planning necessitates more information concerning the organization's external environment, information concerning the external environment should be increasingly more summarized and selective as the

[6] George R. Terry, *Principles of Management*, Richard D. Irwin, Inc., Homewood, Ill., 1964, p. 238.

EXHIBIT 2 MANAGEMENT LEVELS RELATED TO PLANNING CONTROL AND INFORMATION: RELATION OF MANAGERIAL POSITION TO (a) TIME SPENT IN PLANNING AND CONTROL, (b) SUMMARIZATION OF INFORMATION.



(a)



(b)

position of the receiver decreases in the managerial hierarchy. This situation is depicted in Exhibit 2b.

INFORMATIONAL CONSTRAINTS

The conceptual nature of information systems makes them difficult to study and understand. There are, however, physical systems whose well developed theories may be beneficially extended or applied to information systems. For example, classification was previously contended to be a necessary device for coping with reality. However, classification creates a paradox, for it at once creates and destroys information. The number of classifications regarding a particular event (that is its information potential) are infinite, while classification systems are finite. Thus, classified data loses all information potential other than the potential possessed by the category into which it is placed.

To achieve its total potential (perfect information) an event would have to be classified into an infinite number of categories, which is to not classify at all. Thus, only a finite amount of information is available in a given system; or conversely, a certain amount of information is not available.

The situation is analogous to that of energy in the physical world. The second law of thermodynamics states that in an isolated system the probability that entropy shall decrease is zero (where entropy is the positive measure of disorder). In addition, the conversion of energy from one form to another in a given system is accompanied by an increase in entropy (that is, energy is lost).

The application of these concepts to business information systems makes more obvious some intuitive facts:

1 Information is a function of order.
2 Order, and thus information will not spontaneously increase in an isolated system.
3 The amount of information available in a system is finite; the measure of the unavailable information is a measure of disorder.
4 Conversion of information from one form to another (communication) results in a decrease in available information.

One method of minimizing information loss through communication is to maintain a certain level of redundancy in messages. However, redundancy is related to efficiency of coding or classification by the relationship:

Redundancy = 1 − Efficiency

This relationship reveals that a highly efficient code or message is accompanied by a low redundancy which in turn increases the possibility of loss of information.

To convey understanding, there must be uniformity of meaning of words and numbers used in information systems, and rules or guidelines for the use of resulting abstractions are necessary to assure that the underlying activity is revealed and not obscured or distorted by the reporting process. To this end, the AAA Committee on Basic Accounting Theory proposed five guidelines[7] for the communication of accounting information:

1 Appropriateness to expected use,
2 Disclosure of significant relationships,
3 Inclusion of environmental information,
4 Uniformity of practices within and among entities,
5 Consistency of practices through time.

These guidelines appear to be pertinent to all business information. Other more specific means to improve communication[8] are:

1 Finding out what information is desired,
2 Limiting the quantity of information to the essentials,
3 Highlighting the most important figures on reports,
4 Rounding numbers.

However, communication is much more complicated than has thus far been indicated. Studies have shown that even when executives have all the information they need to make a decision, they do not always make the correct one. These failures are thought to occur either because the executive does not know how to translate information into effective action or because the information has not been adequately communicated to him.

Some feel that the answer is to be found in a better understanding of the manager himself and how he thinks and works. The information purveyor must fit his reports to specific individuals.

VALUE OF INFORMATION

There are various approaches to the problem concerning the value of information. One approach to the information collection problem centers on the minimization of the sum of two costs: the cost attributable to decision error, and the cost of assembling and analyzing the required information. The information system is restricted by economic limitations to the accumulation of useful information only, and the measurement of usefulness depends upon the

[7] American Accounting Association, *A Statement of Basic Accounting Theory,* American Accounting Association, Evanston, Ill., 1966, p. 13.

[8] Harold W. Jasper, "Future Role of the Accountant," *Management Services,* January-February, 1966, p. 53.

ability to relate the cost of gathering information to the benefits received. This approach is ideally correct, but the determination of the requisite costs necessary in applying this approach is in many cases impossible. Many authorities have termed this type of approach impractical and so general as to be useless. More rigorous approaches based upon this philosophy have recently been formulated, but are beyond the scope of this paper.[9]

The following are some non-dollar value guidelines[10] for evaluating information:

1 Information must influence decisions.
2 Increasing the accuracy of information increases the cost.
3 Timeliness influences costs.
4 Shorter delays mean higher costs.
5 The systems capacity affects the cost value of the information.

A pragmatic approach is taken by Kirk who states that a value can be assigned information by simply asking, "How much does this piece of information reduce my uncertainty in this decision situation?"[11]

Adopting a pragmatic approach, information is seen to acquire significance (that its value is increased) only when it is used in conjunction with or judged by comparison with:

1 Other current measures
2 The same measurements in previous periods
3 Standards or targets
4 Forecasts
5 Parallel activities elsewhere[12]

The value of information presented in reports can be increased by maximizing their psychological impact and usefulness to managers. Doris Cook[13] recently surveyed the attitude of managers towards certain aspects of performance reports. Based upon her findings, she proposed that the usefulness, and thus the value of performance reports can be increased if they:

1 Are provided as frequently as costs and other circumstances permit
2 Are provided as soon after the end of a reporting period as possible

[9] For example see: Norton M. Bedford and Mohamed Orsi, "Measuring the Value of Information—An Information Theory Approach," *Management Services*, January-February, 1966.

[10] Rudolph E. Hirsch, "The Value of Information," *The Journal of Accounting*, June, 1968, pp. 42-43.

[11] Andrew Kirk, "Company Organization and Control," *Management Accounting*, England, February, 1966, p. 63.

[12] J. A. Scott, "The Measurement of Performance in Industry," *The Cost Accountant*, England, April, 1963, p. 131.

[13] Doris M. Cook, "The Psychological Impact of Certain Aspects of Performance Reports," *Management Accounting*, July 1968, pp. 33-34.

3 Give appropriate credit for favorable performance
4 Include, if possible, the reasons for reported below average performance
5 Provide as much detailed information as specifically needed by each recipient
6 Include only controllable items
7 Are accurate
8 Compare actual results with an accurate, fair and appropriate basis of measurement (where possible the quality of the job should also be measured)
9 Emphasize the *exceptional* items which require the attention of the manager
10 Avoid using performance reports as a pressure device to prod the managers continually to increase output or decrease costs

The value of information is also increased when the user has confidence in the information. Confidence is increased if the user generates the information himself. When the user and the generator of information are not the same person, confidence, and thus value, is increased by a knowledge of the method of generation and of the generator.

Confidence in the person or group generating the information can be attained by either a personal acquaintance with, or power over, a person; or through some sort of confirmation of or attestation regarding the reliability of the generator. Confidence in the information itself will be increased when the information and the method of generation are standardized, providing the user has knowledge of the standards and their meanings and limitations. Useful standards will involve criteria regarding the previously mentioned attributes of information in addition to the factors outlined above.

SUMMARY AND CONCLUSIONS

The general functions of information systems are to determine user needs, to select pertinent data from the infinite variety available from an organization's environments, to create information by applying the appropriate tools to the data selected and to communicate the generated information to the user. The nature of and criteria for evaluating management information and the information generating system have been presented. Much more research is necessary regarding the interrelationships of information and decision-making. Such a body of theory would be very useful as an aid to individual decision-making but its greater use would be in the designing of information systems for decision-making in the whole business system.

READING 2 DISCUSSION QUESTIONS

1 Information generation requires four steps. Identify and discuss these steps.

2 (a) Identify the desirable attributes of information mentioned in this reading.
   (b) To have value, information must possess what three attributes?
3 "The amount and type of information supplied to a manager is a function of his position in the managerial heirarchy and of the environment (internal or external) with which the information is concerned." Discuss this statement.
4 (a) What are some non-dollar-value guidelines for evaluating information?
   (b) How can the value of performance reports be increased?

READING 3 THE ALMOST–PERFECT DECISION DEVICE*

Nature speaks with an angry voice in the thin and crystal air of the Peruvian Andes, and everyone listens. It was no real shock to the authorities, then, when one surly day in one violent spring the river went mad: the friendly finger of water pointing to the mountain-top turned suddenly into a boiling ball of vernal thaw that hurtled down the hill and burst on a small village below. In seconds, generations of labor were lost. Homes were smashed, crops were swept away, and the villagers themselves were tossed aside by raging nature as flotsam on a sea of confusion.

But within hours, a transfusion of food, clothing, medicine, and willing labor flowed into the stricken town as smoothly and calmly as if the disaster itself had been planned in advance. Shortly the houses were rebuilt, crops replanted, tools resupplied, and the armed truce with nature was on again.

Our own morning newspapers would hail such a feat as a miracle of modern teamwork and computer-age technology in planning. But this miracle did not happen yesterday. It occurred nearly five hundred years ago in the isolated land of the Incas, in a society totally without modern communication, without a written language, without money, without even the wheel. The civilization had everything we would consider vital to organized effort—all based on the most sophisticated, efficient method of collecting, analyzing, and acting on information the world had ever seen to that point. But this society was efficient to a fault . . . a fatal fault.

This half-forgotten world of the Inca aborigines is being examined today, for it appears to have been the classic welfare state . . . with all the unchecked efficiency, womb-to-tomb security, and chilling freedom from choice projected for us by Geoge Orwell in his best-seller, "1984." Even omnipotent, omnipresent "Big Brother" . . . the ultimate machine . . . was there pointing to the future in astonishing apocalyptic clarity.

The Inca "Big Brother" was personified by the "Inca" himself, the son of the

*Reprinted from *INPUT For Modern Management,* vol. 4, no. 2, pp. 3-7, 2d Quarter, 1968. Reprinted by permission from UNIVAC Division, Sperry Rand Corporation, New York.

sun: an absolute despot who ruled through four centuries and in 13 temporal bodies over an empire as large as Alexander the Great's . . . but with far better organization and a great deal more enlightened benevolence. His extraordinarily efficient system of continuous recordkeeping gave him an apparatus of wise and knowledgeable decision almost instantly applicable to any of his 16 million subjects in a 380,000-square-mile domain. He commanded one of the best-organized, best-equipped, most powerful armies of all time. Historians rank him as a conqueror with Alexander, Genghis Khan, and Napoleon.

Yet this army and this empire fell to 180 tired Spaniards. Speculation on the cause of incredible success followed by overnight failure centers on the Inca's key to power . . . his apparatus of decision . . . a queer collection of string called a *quipu* (pronounced "kee-poo").

Contemporary reporters who followed the Spanish conquerors into Peru pinpointed the quipu at once as the empire's strength. "Everything that could be counted, was counted . . . and thus does the Lord Inca decide things," marveled one priest from a world where statistical ignorance was taken for granted. The fact that knowledge of the age, marital status, health, and location of every human being—the number and condition of every animal, all crops, clothing, and weapons—was information that could be *used* to advantage . . . was a revelation. That it could be kept up-to-date was simply unbelievable.

The word "quipu" means "to knot," and the basic record was a knot in a string. The color, size, and relative location of the strings attached to one master rope, plus the knots tied in them, made infinite combinations possible to represent the most detailed subdivisions of information.

For example, yellow threads were for gold, white for silver, and red for warriors. Objects with no special colors were arranged in order of importance; in case of weapons . . . spears, darts, bows and arrows, clubs and axes in that order. People were accounted for on separate threads by age group and sex, from the oldest to the youngest. A fine thread tied as an off-shoot to a string indicated an exception to the rule; to represent, for example, the number of widows in a village, a thread would be attached to the proper string for married women of a given age group. The knots were arranged according to a decimal-decade system, in units of ten to tens of thousands.

Raw information was transmitted to the capital city of Cuzco by quipu, and resulting orders were returned via the same vehicle. To expedite the flow of information, a 1500-mile system of roads criss-crossed the empire. (The Spanish simply gave up trying to describe the amazing system of bridges, tunnels and roads through some of the most mountainous country in the world. "Such a gigantic achievement no single description suffices to describe them," was one lame summary.)

Post houses were set up about a mile apart on the roads to accommodate the Royal Runners. Thus messages flowed to and from Cuzco at 12 miles per hour 24 hours a day.

To avoid a traffic-jam of quipus at the capital, the people themselves were organized along the same decimal-decade lines. The basic unit was the family, and each group of ten families was governed by a quipu-keeping administrator, who in turn was governed by a super-administrator of ten groups of ten, and so in a precise pyramidal hierachy. Provincial total quipus were sent to the capital for inclusion in the master quipus. Each major area of interest, such as people, food and clothing, production and supply, and arms had its own system of quipus.

Constant interchange of pertinent economic information assured strict obedience to the law of supply and demand. Precise information on the number of people in a given area, for example, made it easy to determine how much wool should be sent for clothing from the royal storehouse, and how much should be taken from which sheep to replenish the supply. Thus in this perfect planned economy nobody ever wanted for food, clothing, and shelter.

In practice, each person was required to produce exactly three times as much as he himself needed to survive. One third he kept; one third went to the state for the support of the civil bureaucracy, the army, and the needy; and the final third went to the Inca to maintain the royalty and the priesthood. There was no formal taxation, no money, no credit, no debts—personal or national.

In fact, the Inca's direct, pragmatic approach to all problems virtually eliminated many social and economic problems common to all societies.

In a world where black was black and white was white, every predictable problem yielded quickly to mathematical absolutes. But inevitably, one day the *unpredictable* arrived . . . by ship.

In 1532 the Spanish explorer Francisco Pizarro landed near Tumbez with 180 soldiers and paralyzed the empire by kidnapping the last Inca, Atahuallpa. Realizing his predicament, Atahuallpa offered to ransom himself by filling his jail cell with gold. The offer was accepted, and the Royal Runners fanned out with quipus from Cuzco on the last direct order of the Inca . . . a task that proved to be an errand of treachery. The ransom was delivered as promised, but the Inca was not released. On August 29, 1533, the Spaniards strangled Atahuallpa on trumped-up charges and put one of their own in his place.

For a time, the empire functioned as smoothly as before. The Incas had learned to obey the quipu without question, regardless of who tied the knots. but ultimately, Spanish greed corrupted the simple society and the proud Inca warriors slipped meekly into serfdom without raising a hand against the foreign plunderer.

The quipu-oriented society thus demonstrated what "1984" and Big Brother could bring. In centuries of material utopia the pragmatic, the immediately practical had become the only imperative. Problems had vanished, but so had progress. Insecurity did not exist, but neither did the consciousness of gainful choice. There was want of nothing, but nothing was wanted.

The society was incredibly static and dedicated to maintenance of the status quo. It could not accommodate sudden change from outside its own fixed parameters. It was as vulnerable to outside infection as the unvaccinated are to the invasion of a foreign virus. This was the fatal flaw of the Inca civilization: it functioned magnificently as long as nothing changed within its own frames of reference, but collapsed totally with any significant deviation from established ground rules. Innovation was incomprehensible.

The Inca did, however, contribute to modern technology *the basic three-part structure of successful decision-making:* a man of decision, a functioning mechanical apparatus of decision, and a means of expanding to accommodate expanding amounts of information.

Today the modern corporation or government still needs all three elements for successful decision-making. But unlike the quipu or Big Brother, the modern mechanical apparatus of decision serves a society *based on*, actually dependent on, rapidly accelerating basic *change*. The modern computer is not a means of controlling the limits of a fundamentally static situation, but is our most sophisticated tool in stimulating profitable change, choice, and progress.

If need be, today's "quipu" might help predict when that friendly Peruvian river was likely to rebel again. Certainly it could assist in working out new and creative ways to keep it from flooding at all.

If history had given him the chance, perhaps that brilliant but proud pragmatist, the Inca, Lord of the World and Man of Decision, might have deemed this a pretty good practical idea, and probably would have "programmed" his quipu into the new concept.

READING 3 DISCUSSION QUESTIONS

1 What is a quipu?
2 How did the Incas' system work?
3 Why did the Inca civilization fall to 180 Spaniards?
4 What is the basic three-part structure of successful decision-making?

READING 4 IBM vs. REMRAND*

GEORGE SCHUSSEL

Until the end of the 1950's, two American firms, IBM and Remington Rand Inc.

*Reprinted from *Datamation,* vol. 11, pp. 54-57, May, 1965. Reprinted by permission from F. D. Thompson Publications, Inc., 35 Mason St., Greenwich, Conn. Dr. Schussel was a Harvard graduate student at the time this article was written.

(now Sperry Rand Corp.) dominated the world market in the field of digital electronic computers. Their struggle for pre-eminence in selling, leasing, and installing computers is the focus of this article.

In the spring of 1951, the division of Remington Rand that had formerly been the Eckert-Mauchly Computer Corp. delivered and placed into operation the first large-scale, commercially-available computer. That computer, a Univac I, was delivered to the U.S. Bureau of the Census. Indeed, the first large-scale computers sold to private enterprise for non-scientific uses were Univac I's. Starting in 1952, systems were sold to Sylvania, General Electric, Prudential Insurance, Home Life Insurance, A. C. Nielson, Inc., and others. By the end of that year, RemRand had acquired Engineering Research Associates (ERA) which, with the Eckert-Mauchly group, was one of the two foremost companies in the field of electronic computing.

Meanwhile, IBM was the leading office machinery company in the world, and RemRand was considered merely a "tag along in the punched card field."[1] Until 1956, when IBM brought out the model 704 computer, there were no machines on the market that were technically superior to the Univac I.[2] Although IBM had built the world's first computer (Mark I), RemRand, with the Univac, was clearly the outstanding company in the world for computer-based data processing and large-scale computing from 1951 to 1956. By 1957, however, RemRand had lost its position of dominance to IBM; by 1960, the Remington Rand Univac Div. of Sperry Rand was a secondary force in the computer market.

It (IBM) has installed more than three-fourths of the computers in the world—an estimated 13,000 to 14,000—or more than 10 times the tally of its nearest competitor, Univac . . . It has over 19,000 data processing customers . . . [3]

IBM is the business image of one man, Thomas J. Watson, Sr. For 42 years, until his retirement in 1956, T. J. Watson was the head of the International Business Machines Corporation. The company, which he molded, is a reflection of his beliefs from research to sales. Although there is a general consensus, among those who work and have worked for IBM, that it was Watson, Sr., who initially prevented the company from entering the electronic computer business before it did, it is still a reflection of the man and the company that once IBM realized its mistake, it took them only five years to become the outstanding company in the field.

In 1950, IBM was the dominant company in the data processing and office machinery industry. Computers were not yet a factor and at that time its

[1] "Sperry Rand: Still Merging," *Fortune* reprint U2190, March 1960, p. 10.

[2] See the Technical Comparison section.

[3] "Can IBM Keep up the Pace?" *Business Week*, Feb. 2, 1963, p. 92.

dominance was based on electromechanical systems which depended on Hollerith punched cards. IBM's systems were called unit records and only a small amount of electronic equipment was used with the punch card sorters. However, IBM was familiar with the idea of large-scale modern computation. During World War II, its engineers under the direction of Professor Howard Aiken of Harvard University, had built the first computer in the world. This machine was the electromechanical Mark I and was presented to Harvard by IBM. Mark I was put into operation, 24 hours a day, 7 days a week, in the basement of Harvard University's Cruft Laboratory. By 1946, when it was moved to the Harvard Computation Laboratory, the Mark I had revolutionized the calculation of mathematical tables.

The Mark I has been described as several large calculating machines strung together and operated by paper tape. This description may have some validity; however, it remains true that this machine was the first large-scale general-purpose computer that had internal storage and logical abilities. The one most important difference between the Mark I and modern day computers lies in the speed of operation. It could do on the order of one to ten calculations per second.

The next machine of this type that IBM built was the Selective Sequence Electronic Calculator, completed in 1947, which used tubes and relays and was capable of conditional branching.

Neither was exploited for commercial uses. The first large-scale data processing system that IBM developed for sale to the public was the IBM 701 Data Processing System. The development of this computer was begun at the end of 1950 and one model was put into operation late in 1951. The first production machine was delivered at the end of 1952, about 20 months after Remington Rand had delivered its first large-scale system, Univac I.

REMINGTON RAND'S FIRST COMPUTERS

In 1950, Remington Rand was the second largest manufacturer of office equipment in the United States. It competed with IBM along almost the entire range of office machinery. Remington got into the calculating machine business by buying out two small companies that had pioneered in this area.

In 1950, James Rand, the head of RemRand, bought out the company formed by two University of Pennsylvania professors, John W. Mauchly, a mathematician, and J. Presper Eckert, an engineer and genius in electronic circuitry. The Eckert-Mauchly Computer Corp. had already contracted to sell a computer to the Bureau of the Census. This computer was the Univac I.

Univac I was the direct descendant of two other computers that had been built at the University of Pennsylvania, Eniac and Edvac. Eniac had the special purpose of computing firing and ballistic tables for the Aberdeen Proving

Grounds of the United States Army Ordnance Department. This computation required the integration of a simple system of ordinary differential equations involving arbitrary functions. The Eniac was completed in 1946 and thus became the first large-scale all electronic computer. In one sense, however, this machine was not a full-fledged computer. Elaborate preparation of the wiring was required each time that the problem changed slightly. These connections required from 30 minutes to a full working day to set up and constituted a serious limitation of the system.[4] Because it was not programmed internally, the Eniac was conceptually inferior to the Mark I. Nevertheless, it was markedly superior in another characteristic—that of speed. Because Eniac was all electrical, it was much faster. A typical multiplication of the Mark I would require about three seconds, while the Eniac required 2.8 milliseconds.

After working on the Eniac, Eckert and Mauchly helped design the Edvac, also at the University of Pennsylvania. The Edvac was a stored program machine, as opposed to the Eniac; ideas that were incorporated in this machine were used in many other computers, notably the Univac. The Edvac is still in operation at Aberdeen.

Another company that Rand acquired had done some outstanding development work in computers. Engineering Research Associates of St. Paul, Minnesota, specializing in scientific computers, was bought by Remington Rand in 1952. ERA and Eckert-Mauchly were run as separate divisions and were not combined until the merger with Sperry Instrument in 1955.

The computers that were made by these two groups outsold the 701 and 702 of IBM through 1955. In January of 1956, however, IBM brought along and delivered the first 704 and, by the middle of the year, IBM was already decisively ahead of RemRand in computer sales.[5] By one year after the Sperry Rand merger, in June of 1955, IBM had delivered 76 large machines to 46 for Univac and had firm orders for 193 against Univac's 65.

WAS IBM BEHIND?

Considering the prior performance and position of IBM in the data processing industry, many people were surprised that RemRand was the first company to embark on all-out computer development, thereby capturing the initial market. However, the extent of IBM's temporary lag is not as great as generally held. The facts do suggest that had the decision to enter computers been made early enough, IBM could have been the leading company from the start.

[4] R. Serrell, "The Evolution of Computing Machines and Systems," *Proceedings of the IRE,* May 1962, p. 1045.

[5] c.f., *Fortune,* p. 6.

IBM did not stop all of the developmental work on computers after it built the Mark I. Its Selective Sequence Electronic Calculator went into operation in December of 1947. This machine was not entirely electronic, according to modern definitions, as it used relays as well as tubes; however, it was fairly modern in concept. By 1948, IBM had developed an all-electronic calculator of small size, the 604; and in the period 1948—1949, it combined this machine with an accounting machine to make a data processing system (IBM Card Programmed Calculator). All these developments took place before Univac was developed and, although neither of these machines was in the same class as Univac, they showed that IBM had acquired knowledge that would prove transferable to a more sophisticated calculator.

The first IBM machine directly competitive with the Univac was the 701. IBM had an operating model late in 1951 and delivered the first production model at the end of 1952. By comparison, the first Univac was put into operation for the Bureau of the Census in the Spring of 1951. This model, however, was not a production model and it was further changed before deliveries to firms commenced. The reason that IBM was not further behind than about one year was that it kept the development time on the 701 down to a remarkably small period. Development of the Univac was started in about 1947 and the first working model was operating in the spring of 1951. IBM began development of its 701 at the end of 1950 and its first working model was in operation by the end of 1951.[6]

THOMAS J. WATSON, SR.

To understand why IBM did not get into this field earlier, it is necessary to understand why Thomas J. Watson, Sr., did not want to commit his company to the development of computers.[7] This fact is reasonably well documented, but the reasons for it are not. Watson, Sr., was opposed by his son, the present chairman of the board at IBM, who was the leader of the group that tried to push his father into wholehearted backing of the electronic computers.

> *Eventually, though, dissension about computers came into the open in IBM. The argument put the younger Watson (who became executive vice president in 1949) in the unenviable position of leader of the progressive element that wanted to plunge into computers—with his father, Thomas Watson, Sr., then chairman and chief executive officer, counseling caution and refusing to put*

[6]Serrel, op. cit., p. 1050.

[7]Belden & Belden, "The Lengthening Shadow—The Life of Thomas J. Watson," Brown, Little & Co., 1961.

the bulk of the company's resources behind a major computer development program.[8]

Watson, Sr. was a salesman and he did not want his company going into anything that would not prove commercially successful. The first computers that IBM built, Mark I and SSEC, were not in any way designed for commercial exploitation but were built only as a showcase for IBM engineering talent. Watson, Sr. thought of these machines as gifts to science and education. For example, he gave the Mark I to Harvard University. Watson did not believe that computers had commercial possibilities. Actually, in 1950, very few people believed that the market for computers would grow to its present day size.

Just 13 years ago, electronic computers were a curiosity to most mathematicians, statisticians and scientists. Most predicted that eight or 10 of the big electronic brains—which then had about a hundredth of the power of one large-scale computer today—would satisfy the needs of the entire scientific community and the few businesses that might be able to use their strange talents.

This market miscalculation—one of the worst, yet most important, ever made—was accepted by most businessmen in 1950, including the top echelon at IBM. The worldwide market that has grown to about $3-billion a year for electronic computers and other equipment associated with automatic data processing was not recognized by most of the companies then qualified to develop the new technology.[9]

Even as late as 1956, market projections were sadly off. In 1956, an excellent and thoroughly comprehensive study of the industry was prepared by Arthur D. Little Inc., in cooperation with White, Weld and Co. It included technical comparisons of computers then on the market, estimation of market potential, backgrounds of the companies building computers, uses of them, etc. The report estimated that total future purchases of computers for all business, science and engineering, and government uses would total $2.4-billion. The study later hedged slightly by saying that "The $2.4-billion market will also tend to grow because of general economic expansion and replacement of obsolescent equipment." Considering that only seven years later the market for electronic computers had grown to $3-billion a year, it is obvious that market estimation by the most qualified experts was considerably off even in 1956, let alone in 1950.

INITIAL HESITATION

In trying to analyze IBM's initial reluctance to enter the electronic computer market, one should also take into account the company's background and

[8] *Business Week,* op. cit., p. 93.
[9] Ibid, p. 92.

experience. IBM was not a company with a great deal of electronics experience. Most of its earlier equipment and experience had been electromechanical.

The same remark may validly be made about the Remington Rand Corp. If anything, RemRand was less knowledgeable about electronics than IBM was. The card systems that IBM had been marketing were electromechanical devices and used electrical contacts to activate the mechanisms. RemRand's punched card systems were mechanical. Pins were used to drop through the card holes and the information was conveyed by mechanical devices. RemRand, however, did not attempt to go into the field of electronics; it got into the field by buying other companies.

By buying out technologically skilled companies, RemRand gained a lead which enabled them to acquire most of the first sales. Remington Rand did have a lead; they did have a superior computer. Why, by 1956, was IBM outselling Remington Rand in computers? And why, by 1963, had IBM sold and installed over 10 times as many calculating machines as Rand?

The answer to these two questions serves as the focal point for the rest of this article. Differences in company organization, background, attitudes, and policies played an important role, as did marketing and technical factors.

WHY IBM SUCCEEDED

One of the principal differences between Remington Rand and IBM was in organization. While IBM had developed an in-house capability, Remington Rand, and then Sperry Rand, were in the computer business through acquisition and merger. In IBM, the calculator had emerged naturally from the research and engineering done. The computer divisions at RemRand, on the other hand, went through at least two assimilations and complete changes of management within six years.

The computer organization that Sperry Rand inherited from Remington proved to be a large disappointment for the executive officers of the new Sperry Rand Corporation.

> *Vickers (Sperry Rand president) and his Sperry executives knew about computers for complicated weapon systems; they knew nothing about making and selling Univacs for business. Vickers took it for granted that he had acquired from Rand, along with the machinery, all the kinds of talent he needed for such merchandising. He knew, of course, that Jim Rand had run a one-man show for years, but he was completely unprepared to find Remington Rand so thinly organized. Soon it became apparent that nothing short of a complete reorganization was required, and Vickers began to move very cautiously and deliberately to get this done. He moved so slowly, however, that at times it appeared he was not moving at all. It must be remembered that James H. Rand, although sixty-nine years old in 1955, when the merger took place, was still a man of great force and strong character, that he did not retire*

as active head of his division until April, 1958, and that he remained as a director of Sperry Rand until February of last year (1959) [sic].[10]

When RemRand merged with Sperry, the merger was in many ways one of name more than of fact. Of course, merging the personnel, objectives, and resources of two companies as large as Sperry and Remington Rand was an extremely difficult proposition. RemRand's computer division continued to operate autonomously but under the direct control of James Rand.

Early in 1958, Vickers finally began to act. He asked his old friend and colleague, Kenneth Herman, president of the Vickers division, to become executive vice president in charge of the Rand group. Vickers knew that under Herman's rather benign exterior lay great persistence, and that was needed. Less than four months after Herman took over, James Rand resigned. He chose his fiftieth business anniversary at seventy-one, as the date. Probably only Rand, Vickers, and Herman know the whole story of Rand's retirement, and they aren't talking.

IBM reacted to the challenge to its leadership in another manner.

The loss of our business in the Census Bureau struck home. We began to act. We took one of our best operating executives, a man with a reputation for getting things done, and put him in charge of everything which had to do with the introduction of an IBM large scale computer—all the way from designing and developing to marketing and servicing. He was so successful that within a short time we were well on our way.[11]

Thus, IBM's organization was completely centralized, as opposed to the RemRand system, where the groups that were formerly ERA and Eckert-Mauchly operated separately.

The two organizational policies seemingly present a paradox. In order to operate efficiently and with maximum speed, the management at IBM decided to adopt a centralized type of control, while the group at Sperry Rand believed that it had to "dismantle the one man show" before it could operate successfully.

There are important distinctions, however, that need to be made. The initial responsibility for getting the computer program under way was given to one man at IBM. Once the system was set up, it was a major goal of the IBM management to decentralize the whole company as well as the computer division. Speaking of the three-day session in 1956, when the whole organization of IBM was changed,

[10] *Fortune,* op. cit., p. 6.

[11] T. J. Watson Jr., "A Business and its Beliefs," McGraw-Hill, 1962.

Thomas Watson, Jr., said: "We went in a monolith, and we emerged three days later as a modern, reasonably decentralized organization, with divisions with profit responsibility and clear lines of authority."[12]

> *Even after this subdivision of the monolith, the reorganization was not complete. Going into 1957, IBM had one large and four small divisions. . . . The big one, Data Processing Div., which made and sold unit record systems and computers, was doing a $700 million-a-year business by 1958—larger than IBM itself before the reorganization.*
>
> *The monster Data Processing Div. now had to be split—though DP people insisted it couldn't be done logically. Watson (Jr.) and his top aides labored at it a whole summer, tried various methods, found none that worked. Eventually, they did find a way—and out of the split came IBM's present form.*[12]

The situation at RemRand was quite different. Its computers were never under anyone lower than top management on the corporate level. The responsibility for their success was centered at the very top, in James Rand. Judging from the results, Rand was not able to integrate the efforts of his divisions effectively.

FAST REACTIONS

IBM's ability to react rapidly to a changing environment was also due to their organization. Repeatedly, IBM would show this talent once they realized the need for a change. IBM's first large commercial computer, the 701, is an excellent example of this. IBM executives realized the need for a machine of this type in 1949 and the total time from the start of development to the first production model was about two years. Another good example of rapid development of a computer preceded this.

> *The IBM Card Programmed Calculator line descended from the connection, made for Northrop Aviation in 1947—1948, of a multiplier to an accounting machine tabulator. . . . In 1948—1949, an IBM group produced the models I and II Card Programmed Calculator (sic) by connecting an IBM 604 to an IBM 402 Alphabetic Accounting Machine.*[13]

The CPC was more of an adaptation of existing elements than an original development, but it was a versatile machine, models of which were still in use in 1960.[14]

[12] *Business Week,* op. cit., p. 94.
[13] Serrell, op. cit.
[14] For example, the Bay State Abrasive Co. in Massachusetts.

This ability to react quickly was prevalent throughout the IBM organization. An IBM consultant related that a working model of the completely redesigned electric typewriter, brought out in 1948 by IBM, had been designed and built in two months.

READING 4 DISCUSSION QUESTIONS

1 (a) Discuss the development of the Mark I.
  (b) How did ENIAC differ from the Mark I?
  (c) Who was Thomas J. Watson, Sr.?
2 Why was IBM reluctant to enter the computer market?
3 Why was IBM successful in spite of a slow start?

SUMMARY OF CHAPTER 1

Future managers must prepare for successful working relationships with computerized information-processing systems. The primary purpose of this book is to provide an insight into the broad impact which computers have had, are having, and may be expected to have on managers and on the environment in which managers work.

Management information is relevant knowledge, produced as output of data-processing operations and acquired to achieve specific purposes. It is basic to the conduct of business; it is needed by managers to support the decisions which must be made if organizational goals are to be achieved. Although the information needed by managers can only be described in broad general terms because individual managers differ in the ways in which they view and use information, it is possible to identify the desirable properties of management information. To be of value, information should be accurate, timely, complete, concise, and relevant. In seeking to design systems which provide these characteristics, however, designers should not build upon the false assumptions identified by Professor Ackoff in his article. Nor should they ignore costs in an attempt to obtain unnecessary accuracy or unwarranted shorter information periods.

The processing methods used to produce management information have evolved from manual to electronic techniques. Each processing method has its place in data processing. Mechanical tools have been developed to extend man's capabilities in performing specific steps. Later mechanical and electromechanical devices enabled man to combine some steps in one operation. The computer, with its ability to store and act upon its own instructions, made possible automatic communication between processing steps. First- and second-generation commercial computers were produced between 1951 and 1964. Current models are of the third generation.

THE INFORMATION-PROCESSING REVOLUTION

History records, in a relatively unfavorable light, periods in which the tempo of change has diminished. For example, we are told that, during the centuries known as the "Dark Ages" following the fall of the Roman Empire, an attempt to preserve the status quo against change was made by European political and religious leaders. But there were also periods of dynamic change as well as men and nations who were able to meet the resulting challenges. The Dark Ages eventually gave way to that period of reawakening and accomplishment known as the "Renaissance" and the "Age of Exploration." The pages of history are filled with accounts of men of courage and foresight who, during the dynamic periods, emerged to create change or to meet the challenges brought by changing conditions.

Unfortunately, the footnotes of these pages often contain accounts of men who failed to respond to the changes taking place around them. At the turn of the nineteenth century, some members of the British Parliament argued that since the important inventions had all been made, there was no further need to keep the Royal Patent Office open. Since, of the top 25 United States businesses at the time of this British debate, only two are still ranked that high, it is apparent that the business managers of that time, on the whole, possessed no greater foresight than did the politicians. To illustrate, Vincent Learson, president of IBM, notes that in the early 1900s the keynote speaker at the annual meeting of the National Association of Carriage Builders delivered the following encouraging message to the assembled buggy manufacturers:[1]

> *Eighty-five percent of the horse-drawn vehicle industry of the country is untouched by the automobile. In proof of the foregoing permit me to say that in 1906-7, and coincident with an enormous demand for automobiles, the demand for buggies reached the highest tide of its history. The man who predicts the downfall of the automobile is a fool; the man who denies its great*

[1] Quoted in T. Vincent Learson, "The Management of Change," *Columbia Journal of World Business*, vol. 3, p. 59, January-February, 1968.

necessity and general adoption for many uses is a bigger fool; and the man who predicts the general annihilation of the horse and his vehicle is the greatest fool of all.

Nor were the buggy builders the only ones in the transportation industry to be surprised. A top executive for the leading steam-locomotive manufacturer was quite certain thirty years ago that the diesel locomotive had only limited application. In his words, "the field of probably profitable application of the diesel locomotive is pretty generally indicated at work speeds not exceeding 10 miles an hour."

These examples point out to business managers the importance of being prepared to cope with environmental changes. Yet the *scope* and *pace* of the environmental changes occurring today is *unprecedented* in history. Revolutionary technological, social, and economic forces are at work; managerial techniques which were adequate in the past may not continue to be effective; the risks of failure and the rewards of success are probably higher than they have ever been. The basic challenge to the managers of today is to foresee and manage (and not be swept along by) the flood of changes facing their organizations, within a democratic framework, for the benefit of society as well as for the benefit of customers, employees, and owners. The names of managers failing to meet this challenge may someday be placed in the footnotes of business history books in company with the spokesmen for the buggy and steam-locomotive builders.

In this chapter we shall first examine the *revolutionary environmental changes* facing business in scientific, social, and economic areas. Obviously, coping with accelerating change requires higher-quality managerial information. We shall then look at the *technological improvements in the computer field* which are constantly improving the information-processing capability of this management tool. Finally, we shall examine the new *business information* systems which are making use of recent computing advances to revolutionize traditional methods of preparing and presenting information.

REVOLUTIONARY ENVIRONMENTAL CHANGES

SCIENTIFIC CHANGES

World War II and the cold (and hot) war years which have followed, have provided much impetus for scientific discovery and technological change. During World War II, for example, the multibillion-dollar Manhattan Project led to the atomic bomb; ballistic missiles were produced; research in the realm of electronics led to radar and improved communications and weapons systems; and ENIAC was built for the U.S. Army by Mauchly and Eckert to compute

artillery trajectory tables. Since World War II, these breakthroughs, in turn, have led to computer-based early-warning command and control systems, to the development of new electronic circuitry, and to the beginning steps in the conquest and exploration of space. Peaceful application of defense-inspired discoveries have resulted in new commercial materials and products.

In short, during an extremely short span of time in the history of man, the *broadening scope* of scientific inquiry has resulted in movement along such paths as space exploration, increasing use of nuclear power, laser experimentation, and molecular biological research probing toward the secrets of life itself. As a result of an expanding scope of scientific inquiry, there has been an explosion in the amount of available scientific knowledge. (After all, 90 percent of all the scientists and engineers ever formally trained are alive today!) It is estimated that there are 5 million articles of a technical nature now being published annually. It is further estimated that there is a 5 percent annual growth rate in the output of scientific information. Thus, in about fifteen years (because of compounding) the amount of such information will have again doubled. *Information retrieval* has therefore become a major problem in many scientific and business areas. Researchers may spend considerable time and money on problems which, unknown to them, have been solved and published elsewhere. Much work is currently being done in the field of computer-assisted information retrieval systems.

In addition to an expansion in the scope of scientific inquiry, there has also been a great acceleration in the *speed or rate* with which new knowledge is put to use. The Department of Commerce estimates that prior to World War I there was an average wait of thirty-three years between an invention and its application; by World War II, the lag time had dropped to ten years; and now the delay has been further reduced. For example, the laser was invented in 1958 and was being applied seven years later for manufacturing and surgical purposes. And three computer generations have been introduced since the first UNIVAC-I became operational at the Census Bureau in 1951. The implications of an accelerating rate of change are obvious to managers: a major change which might have required five years to implement a decade ago must now be completed in a shorter period if the firm is to remain competitive. Management reaction time, in other words, is constantly shrinking, on the one hand, while on the other hand each decision made involves more risk and is valid for a shorter time span!

SOCIAL AND ECONOMIC CHANGES

Recent scientific change affects the way people live, think, and associate with each other; it also has profound economic implications. In the wake of technological change has come a wave of *social problems*. Creeping urban decay exists in many cities in the midst of wealth; the air and water become more polluted; irritating noise levels move ever higher; traffic congestion becomes

more intense. Increasingly effective communications media tell of the rapid advances being made in space exploration and in other scientific areas. The story of improving living standards is also presented in direct and subtle ways to citizens who have not shared adequately in past progress. The rising expectations which these progress reports engender then come into conflict with the harsh reality of poverty, inadequate housing, lack of opportunity, lack of preparation, and chronic unemployment. The resulting despair often leads to violence and rioting.

A continuing mass migration of unskilled and uneducated farm workers to the cities compounds the urban difficulties and increases the already overcrowded situation. In the relatively brief twelve-year period between 1955 and 1967, agricultural employment dropped 40 percent (from 6.7 million to 4.0 million)! A large proportion of these displaced workers sought jobs in urban areas. As a result of this farm-to-city migration, 70 percent of the population now lives in metropolitan areas on 1 percent of the nation's land area. This population percentage in urban areas is increasing.

These and other social problems call for concerted government action. They will also require that business executives take a more active future role in helping to provide solutions to these social difficulties. The business community can, for example, make a positive contribution by training unskilled workers and giving them job opportunities, and by making sure that its firms are not contributing to environmental pollution. Regardless of the actions taken, it will be necessary to plan carefully to achieve clear objectives. (The last cities left completely to God's will were Sodom and Gomorrah.) New information will be needed by managers to cope with these unsolved ailments.

In addition to contributing to the solution of social problems, managers will also have to carefully assess the effects of changes in the *size and composition of the population*. If the number of people in the world continues to grow at the present rate, there will be a doubling of population between the years 1967 and 2000. Late in 1967, the United States population passed the 200-million mark; in 1910 we numbered only 90 million. By 1975, it is expected that our population will be in the region of 224 million. These additional millions must be fed, housed, clothed, educated, transported, and eventually employed. Business activity obviously must expand to meet (1) the demands of additional population at home, (2) the demands from abroad for American goods and services, and (3) the demands brought about by an improvement in the overall standard of living (which is brought about, in part, by the increased productivity resulting from technological innovations).

The fastest-growing segment of the population in the 1970s will be the 20 to 35 age category. In the early 1970s, the median age will be 26—i.e., half the population will be under 26. Not too long ago the median age was 29. The age category which typically supplies a large percentage of business executives—the 35 to 55 group— will change very little, and there will even be a decline in the

number at the higher ages. Peter Drucker colorfully explains the implication of this fact to top executives in these words: "The age structure of our population is such that in the next 20 years, like it or not, we are going to have to promote people we wouldn't have thought old enough, a few years ago, to find their way to the water cooler."[2] Other implications are that products will be developed or redesigned for (and advertising will be aimed at) the large young market. And the creation of an additional 15 to 20 million new families during the 1970s will bring a significant increase in the demand for housing.

Mass *education* is part of our social picture and is a leading contributor to spiralling change. Why is this? It is because education leads to knowledge; knowledge creates the tools which lead to higher productivity and rising standards of living; and higher standards of living enable man to devote more time to education. Thus the cycle begins anew, but at a progressively higher plane.

Educational attainment, as measured by years of formal schooling, will continue to rise. In 1952, 1 out of 12 in the labor force had attended college for at least four years; in 1975, the comparable figure will be about 1 out of 6 (1 out of 4 will have had some higher education). The knowledge explosion in many fields makes continuing education beyond graduation a necessity.

A better-educated population is potentially more productive, is more mobile, and will have more leisure time and more money to spend in the future. There is also a tendency for well-educated workers to place professional standards above loyalty to, and the values of, the organizations which employ them. Top executives will have to adjust to accommodate and motivate a more independent type of subordinate in the future. What are some of the other business implications of these changes? In the past, increased mobility has brought changes in product-distribution methods. Suburbs have grown and new shopping centers have sprung up. Changes of this type will continue as the labor force reacts to changing geographical demands for labor services. Population mobility is a matter which must be considered by marketing managers. Also, increasing leisure time improves the markets for boats, camping equipment, and travel-oriented businesses.

We noted that future consumers would have more money to spend. This will be true because the value of the tools of production which lead to higher productivity will expand from a 1965 level of $700 billion to a 1975 level of about $1,200 billion. In addition to an absolute growth in productive facilities, existing facilities will be upgraded with newer and more productive capital equipment. The result will be that in the decade from 1965 to 1975, GNP (gross national product, measured in constant dollars) will expand by more than 50

[2] Peter F. Drucker, "The Manager and the Moron," condensed from *The McKinsey Quarterly*, Spring, 1967, and appearing in *Management Review*, vol. 56, p. 22, July, 1967.

percent. The fact that consumers will earn significantly more in the future has obvious implications for business.

The implications of rapid scientific, social, and economic changes are clear—the business manager must be prepared to make continuous readjustments in his plans. He must make more and better decisions about new products and existing products because of their shorter profitable lifespan; he must make decisions about product prices, about new markets, and about channels of distribution to use; and he must decide on matters of finance. Furthermore, he must make these decisions within a time span which is constantly shrinking. To compete profitably in the future will require information of the highest possible quality. The computer, which is undergoing rapid technological improvement, is a tool which can provide the needed information to managers who must operate in a dynamic environment.

COMPUTER TECHNOLOGICAL DEVELOPMENTS

The computer is a tool which is *contributing* to advances in virtually all fields. Computer hardware technology is also *benefitting* from new discoveries in the fields of electronics and physics. Computer *hardware* consists of all the machines which go to make up an operating computer system. Basically, these machines accept data input, store data, perform calculations and other processing steps, and prepare information output.

In addition to hardware, *programs and routines* (or *software*) have been developed and improved to help make more effective use of the machines. Let us briefly look at the technological advances which have occurred in computer hardware and software.

HARDWARE DEVELOPMENTS

Hardware technological development has been extremely rapid, as may be seen by an examination of the factors of (1) *size*, (2) *speed*, (3) *cost*, and (4) *information storage capacity.*

SIZE The earliest computers used vacuum tubes and were large enough to store grain in (ENIAC weighed 30 tons). Using transistors rather than tubes, second-generation computers were significantly reduced in size. Compact tube equipment contained an average of 6,000 *components* per cubic foot. By using cooler operating and more reliable transistors, however, it was possible to pack an average of 100,000 *circuits* into the same space. And the *third-generation* computers now in operation make use of microelectronic or *integrated circuits*, making it possible to jam 10 million circuits into that same cubic foot of space. Furthermore, the extension of microelectronic concepts holds forth the promise

of future *large-scale integration* (LSI) of circuits which will make it feasible to again increase the number of circuits by many times. Such size reductions make it possible to build, in an ever-smaller package, a machine with the computing power of the earlier monsters. That many currently produced computers are also rather large merely gives an indication of the growth in computing capability.

SPEED Component miniaturization has brought increased speed of operation to the latest computers. Why is this? It is because size reduction means shorter distances for electrical pulses to travel, and thus processor speed has increased. Current machines are 900 times faster than 1950 models. A job taking one hour to finish in 1950 could be completed now in three or four seconds. Early computer speed was expressed in *milliseconds* (thousandths of a second); second-generation speed was measured in *microseconds* (millionths of a second); and third-generation hardware has internal operating speeds measured in *nanoseconds* (billionths of a second).

COST The cost of performing a specific number of operations has declined dramatically. Professor Jay Forrester, of M.I.T., has estimated that the cost of performing a million calculations twenty-five years ago on precomputer machines was $30,000; he notes that computers can do the same number of calculations today for 30 cents! And E. L. Harder, of Westinghouse Electric Corporation, illustrates the reduction in computing cost with these words:[3]

> *I use a measure which I adopted many years ago, a calculation requiring two weeks on desk calculators by two engineers at a cost of $300. That gives you an idea of how long ago it was. This calculation can be done today for seven-tenths of a cent on a very large high-powered computer.*

Nor does it appear that the end is in sight in computational cost reduction. Basic hardware-component costs will continue to decline. For example, in 1965 it cost about 20 cents to provide internal storage capacity for one binary number (down from 85 cents in 1960 and $2.61 in 1950). The comparable cost in 1970 is estimated to be from 5 to 10 cents, while the 1975 figure is set at ½ cent![4]

INFORMATION STORAGE CAPACITY Information may be stored for use by a computer in a number of ways. The central processor of the computer holds data and the instructions needed to manipulate the data *internally* in its *primary storage* or *main memory* unit. This primary storage capacity in early computers was quite small (2,000 to 4,000 "words"). With second-generation

[3]E. L. Harder, "The Expanding World of Computers," *Communications of the ACM*, vol. 11, pp. 238-239, April, 1968.

[4]Figures released by American Federation of Information Processing Societies and appearing in *Administrative Management*, p. 53, June, 1966. The figures are averages.

hardware, internal storage was available which exceeded 30,000 words; and current computers can store hundreds of thousands of words in primary storage.

A concurrent and perhaps even more dramatic development has been the improvement in mass *external online* (or *secondary*) *storage devices*. These storage devices are connected directly to (i.e., they are "online" to) the central processing unit (CPU); they accept data from, and return data to, the CPU without human intervention. The data are typically stored in these reference libraries on magnetizable disks, drums, cards, or strips. Access to data is *direct*, i.e., the CPU can quickly obtain access to the information desired without having to search records in a sequential fashion until the one needed is located.

Wide variation exists in storage capacities and in the time required for the CPU to retrieve or store data. Speed is generally sacrificed (but the cost per character stored is frequently reduced) as mass storage capacity is increased. However, *access time* on even the slowest units, while much slower than the nanosecond time of primary storage, is still measured in milliseconds. Maximum online storage capacity in 1956 was about 10 million alphanumeric characters. By 1961, this capacity had doubled, and the next year saw capacity increase to 100 million characters. But with the arrival of third-generation hardware also came the ability to store online over 100 billion characters—a growth factor of 10,000 in one decade![5]

SOFTWARE DEVELOPMENTS

"Software" is the general name given to all programs and routines associated with the use of computer hardware. Unfortunately, when compared with the tremendous hardware advances, the developments in the software area seem less dramatic. In fact, it is quite likely that good supporting software now takes longer to produce than the hardware; furthermore, the pace of software production generally determines the speed with which computer-based projects are completed. As a result, it is a generally accepted fact that the investment in software now exceeds the investment in hardware in most installations. The trend will undoubtedly continue in this direction.[6] Yet there have been impressive gains in the development of software. The three basic software categories are (1) *translation programs*, (2) *applications programs*, and (3)

[5]See Richard G. Canning, *EDP Analyzer*, p. 2, November, 1966. The information storage capacity of machine-readable media such as punched cards and magnetic tape is, of course, unlimited; but the CPU does *not* have direct and unassisted access to the information stored.

[6]Thus, with hardware computation costs declining and with software development costs becoming proportionately larger, programming techniques which are less efficient in terms of machine time have been (and will continue to be) implemented if they help to reduce program preparation time.

operating-system programs. Let us look at the developments in each of these categories.

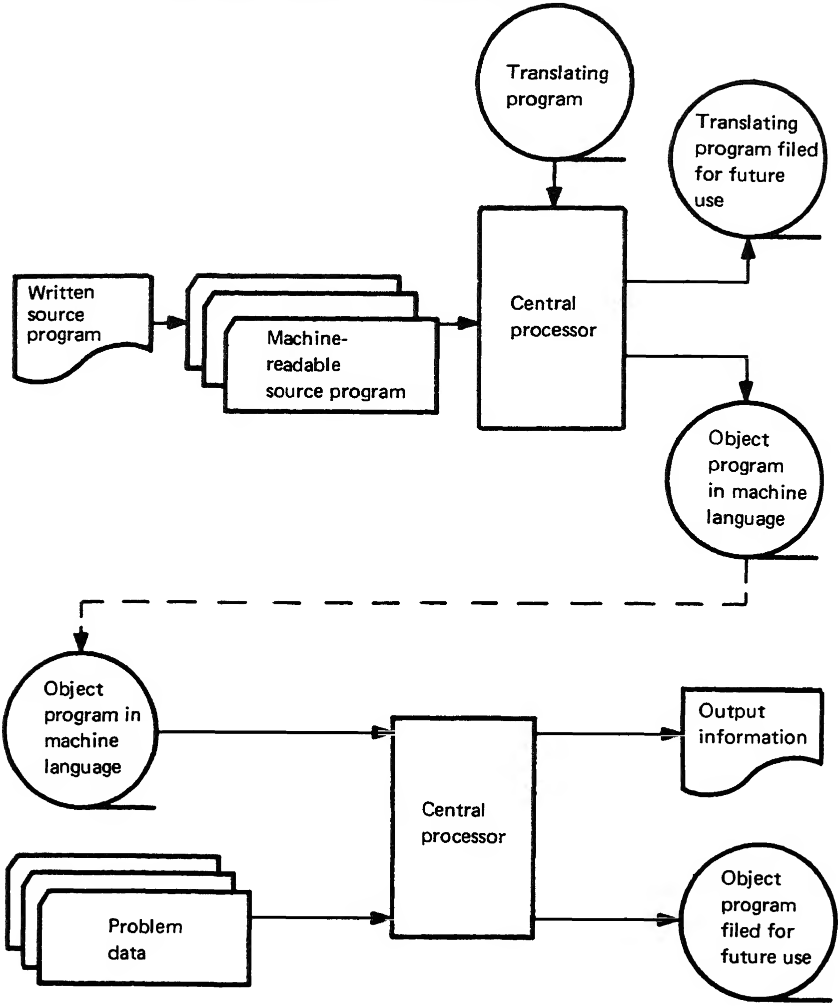
TRANSLATION PROGRAMS In the early 1950s, programmers had to translate problem-solving instructions into special machine languages for each computer. Such instructions typically consisted of strings of numbers (sometimes in a binary form) which were quite tedious to prepare. In addition to remembering dozens of operation code numbers (21 might mean add), the programmer was also required to keep track of the locations in the CPU where the instructions and data items were stored. Initial program coding often took many months; checking instructions to locate errors was about as difficult as writing the instructions in the first place; and modifying programs was often a nightmare. In short, machine-language coding was fine for the machine, but man found it awkward to use.

To ease the programmer's burden, a compromise approach between man and machine was developed which resulted in the introduction first of machine-oriented symbolic languages and then of machine-independent *procedural* languages. Using these languages, the programmer writes his instructions in a form which he finds easier to understand—e.g., he may print the word ADD or use the plus symbol rather than use the number 21. Unfortunately, this code is not in the machine's language, so it does not directly understand the orders. How, then, can the machine execute instructions it cannot understand? It merely takes over the translation task from the programmer and converts his instructions into machine-usable form by means of separate translation software. This software also takes over the detailed job of keeping track of where in storage data items and instructions are located. The translating program (called either an *assembler* or a *compiler*, depending on the programming language used) is stored on cards or on a magnetizable medium and is read into the computer where it has control over the translation procedure (see Figure 2-1). The *source program* written by the programmer is converted to a machine-readable form (e.g., punched cards) and is then read into the computer a card at a time under the control of the translating program. The output of this operation is a machine language or *object program* which can then be read into the computer to control the processing of problem data.

Continuing efforts are being made to produce software which will permit easier man-machine communication. The intent is to develop software which will give the ultimate users of the processed information the ability to prepare programs in languages which are more familiar to them.

Before leaving the subject of translation programs, it should be pointed out that a majority of the programs written today are prepared in higher-level translatable languages. It should also be mentioned that these languages perform an important *compatibility* function. Programs prepared in high-level languages such as COBOL and FORTRAN are essentially machine independent and can be

FIGURE 2-1 PROGRAM TRANSLATION PROCESS



used with a number of different hardware makes and models with little or no modification. This important feature (1) substantially reduces the need to rewrite programs when a new computer is acquired, (2) permits greater exchange of programs, information, and data among computer users, and (3) encourages the commercial development of *packaged programs* designed to process a particular application in a given industry.

APPLICATION PROGRAMS Programs written by computer users, equipment manufacturers, or independent organizations for the purpose of solving

particular processing jobs also come under the heading of software. Such programs are commonly prepared by each using organization to process such applications as payroll, billing and accounts receivable, inventory control, project scheduling, and other tasks. Many applications programs must, of course, be prepared by users to process tasks which are unique to their particular needs. In the past, however, much programmer time (a scarce and expensive resource) has been spent in duplicating programs prepared in other companies. Recognizing the wastefulness of such duplication, equipment manufacturers and independent software companies have prepared generalized *applications packages* (or packaged programs) for widely used applications. Retail stores, for example, sell on credit and thus maintain credit records and perform billing operations. Since many retail firms employ essentially the same accounting procedures in such cases, a billing and accounts-receivable application package may be used with a minimum of modification.

The use of application packages is increasing for a number of reasons, including the facts that:

1 The hardware compatability of new families of computers[7] combined with the software compatibility provided by higher-level languages has furnished added inducement for the development of better packaged programs, since these programs can now be usefully employed by a much larger number of installations.
2 Commercial computer centers have been active in promoting the use of these packages by smaller firms.
3 The packaged program, prepared by excellent programmer specialists, may be more efficient than a run-of-the-mill program prepared by the user.
4 The speed with which applications can be converted to the computer may be substantially reduced. It may, in fact, be cheaper and faster to use certain packaged programs than to reprogram existing applications for a conversion to new hardware.

OPERATING-SYSTEM PROGRAMS It is the function of the computer operator to load data input devices with cards and tapes, to set switches on the console, and to start a processing run. It should not be his job, however, to waste his (and the machine's) time doing things which the computer could do more quickly and reliably. As the name implies, therefore, the *operating system* (OS) was initially a set of programs or routines prepared by the equipment manufacturer to assist the computer operator. Housekeeping duties, such as clearing CPU

[7] For example, several models of the IBM System/360 family are hardware compatible—e.g., programs prepared for the model 30 can be run on the model 40 or the model 50. The same can be said for the RCA Spectra 70 family. Furthermore, programs prepared on several 360 models can be run on Spectra 70 models with minimal modification.

storage locations between jobs and loading into storage the next job program and data, were controlled by the OS software in order to reduce the operator's work, provide relatively nonstop operation, and thus speed up the amount of processing which could be accomplished.

The objective of current operating systems is still to operate the computer with a minimum of idle time and in the most efficient and economical way during the execution of application and translation programs. But the operating software is now vastly more complex. More sophisticated software has been required to keep faster and more powerful hardware occupied. An example is the development of *multiprogramming*—the name given to the interleaved execution of two or more different and independent programs by the same computer.[8] Internal operating speeds of CPUs are now much faster than are the means of getting data in and out of the processor. With multiprogramming, it is thus possible for several user stations to share the time of the CPU. This *timesharing* feature may permit more efficient use of the capacity of the processor. The incorporation of multiprogramming into the operating system has, of course, complicated matters. Operating systems of large new computers are now expected to perform *scheduling, control, loading,* and *program call-up* functions, described below.

1 The *scheduling* function involves the selection of jobs to be run on a priority basis from a table of jobs to be processed. Available storage space and the most suitable peripheral hardware to use is allocated to the job or jobs being processed. Whenever possible, jobs are selected to balance input/output and processing requirements. They are added to and deleted from the job table as required.

2 The *control* function consists of a number of activities including

(*a*) the control of input and output housekeeping operations,

(*b*) the proper handling and shifting of data, instructions, and intermediate processing results when a high-priority program interrupts the processing of a lower-priority program,

(*c*) the timing of each job processed and the allocation of processor time to user stations, and

(*d*) the communication of control messages to human operators.

3 The *loading* function includes assigning storage locations to object programs and data. Checks are also made to prevent the loading and processing of incorrect files.

[8]This may involve allocating a small amount of time—say 150 milliseconds per second—to each program being executed. Fifteen-hundredths of a second may not seem like much time to you, but as Harris Hyman noted in the February, 1967, issue of *Datamation*: "That is enough to solve 20 simultaneous equations, sort 200 numbers into order, calculate the prices of 300 municipal bonds, perform 500 Runge-Kutta integrations, calculate 850 payrolls—all kinds of useful things." The result of such speed is that each user has the illusion that he has the undivided attention of the computer.

4 The *program call-up* function emphasizes the overall control of the OS master program (referred to by such names as *monitor, executive routine,* and *supervisor*) over other software elements including translating programs, utility routines (for loading programs, for clearing storage, for sorting and merging data, for diagnostic testing of new programs, etc.), and the installation's file of applications programs. The monitor integrates this assorted software into a single consistent system. The system monitor generally remains in primary storage; in installations with online external storage capability, many of the other programs and routines are kept online and are called up and temporarily stored in the CPU as needed.

MARKET REACTION TO TECHNOLOGICAL CHANGE

For the past several pages we have been looking at the rapid developments which have occurred in the technology of computer hardware and software. A significant result of these developments has been the rapid growth in the number of computers which have been installed in this country. In 1950, it was generally agreed by executives of firms producing data-processing equipment that eight or ten of the big "electronic brains" would satisfy the entire demand for such devices! This monumental blunder in market forecasting today boggles the mind; the number of computers installed in the United States in January, 1969, was estimated to be 67,200.[9] Furthermore, it is estimated by John Diebold, a leading computer authority, that by 1977 100,000 general-purpose computers will have been installed in the United States, and 80,000 in Europe.[10] Diebold further estimates that by 1970 investment in computer systems will account for about 10 percent of *total* business investment.

THE SHORTAGE OF TECHNICAL PERSONNEL

The rapid and continuing growth in the number of computers installed has, of course, produced a serious shortage of personnel qualified to make efficient use of the machines. Furthermore, the number of people needed in the areas of *data-processing management, information-systems analysis and design,* and *program preparation*[11] will expand significantly in the next few years for the following reasons:

[9] See the monthly computer census, *Computers and Automation*, vol. 18, p. 71, January, 1969.

[10] See John Diebold, "What's Ahead for Computer Technology," an article appearing in *International Management*, October, 1967, and condensed in *Management Review*, vol. 56, pp. 28-31, December, 1967.

[11] We shall examine the duties of these occupational categories in detail in Chap. 6.

1 As we have seen, the number of computers will increase rapidly in the span of a very few years. These computers must be staffed.
2 The workload in existing installations will be increased as additional processing applications in all business areas are converted to the computer.
3 Existing applications will be redesigned and reprogrammed during conversion to new equipment in order to make more efficient use of technological advances in hardware and software.
4 New and faster-responding information systems will be designed to integrate existing and proposed applications in order to provide higher-quality information.

What is the magnitude of the current shortage? According to Dick H. Brandon, an author and leading data-processing consultant, there was a shortage of 30,000 data-processing managers, 35,000 systems analysts, and 60,000 programmers in 1967. He further estimates that an *additional* 70,000 managers, 130,000 analysts, and 100,000 programmers will have to be trained between 1967 and 1971 if the demand for personnel in 1971 is to be met.[12] It obviously will not be met! Looking at just the program-preparation category (and shortages in the other categories will likely be more critical), James Campise, another authority, writes that "the demand for skilled programmers is increasing at 20 to 25 percent per year, while the supply of skilled programmers is increasing at the rate of about 10 to 15 percent per year. . . . In other words, for every 100 programmers practicing today, there will be about 165 practicing in 1972 and enough work for nearly 375."[13]

To summarize, the present shortage of qualified personnel, bad as it is, will only get worse in the next few years. Employment opportunities for skilled data-processing managers, systems analysts, and programmers are, of course, excellent; annual salary levels for these categories are in five figures and are rising rapidly.

The technological advances in computer hardware and software discussed in this section have both contributed to and been stimulated by the rapid environmental changes mentioned earlier. In the final pages of this chapter we shall examine the computer-oriented business information systems which have emerged (and are appearing) because of the desire of managers for effective information which will enable them to operate under conditions of rapid change.

[12] See Dick H. Brandon, "The Dark Side of Data Processing," *Data Systems*, p. 37, July, 1967.
[13] James A. Campise, "The Software Dilemma," *Journal of Data Management*, vol. 5, p. 19, November, 1967.

COMPUTER-ORIENTED BUSINESS INFORMATION SYSTEMS

An unfortunate problem of lack of communication exists today between computer specialists and business managers. This problem stems from the fact that a whole new language has developed in data processing in the past decade. Many new terms and acronyms are being introduced as more familiar words take on different meanings.[14] Confusion results because of the lack of uniform agreement about the meaning of many of the more popular new words and phrases. Such is the case with "business information systems" or "management information systems." These innocent-looking words are defined in dozens of different ways, and the definitions vary in scope and breadth. For our purposes, *business information systems* are networks of data-processing procedures developed in the organization, *and integrated as necessary*, for the purpose of providing managers with timely and effective information. A *procedure* is a related group of data-processing steps or *methods* (usually involving a number of people in one or more departments) which have been established to perform a recurring processing operation. Figure 2-2 illustrates these definitions in the narrow context of information needed by personnel managers. Each line represents a procedure (consisting of a series of steps or methods indicated by the squares) which is directed toward achieving the objective of more effective personnel management. Each procedure produces needed information, and several procedures cut across departmental lines. The "evaluation of performance" procedure, for example, may require the cooperation of supervisors throughout the firm.

Our personnel information system is, of course, only one of several information producing activities in a business.[15] Other activities typically included are those in the areas of accounting and finance, production, and marketing. Thus, information is produced in a number of systems, and the past success of these systems in consolidating this information within an appropriate time frame may or may not have satisfied the total needs of the business. In too many companies in the past, the information needs have not been met.

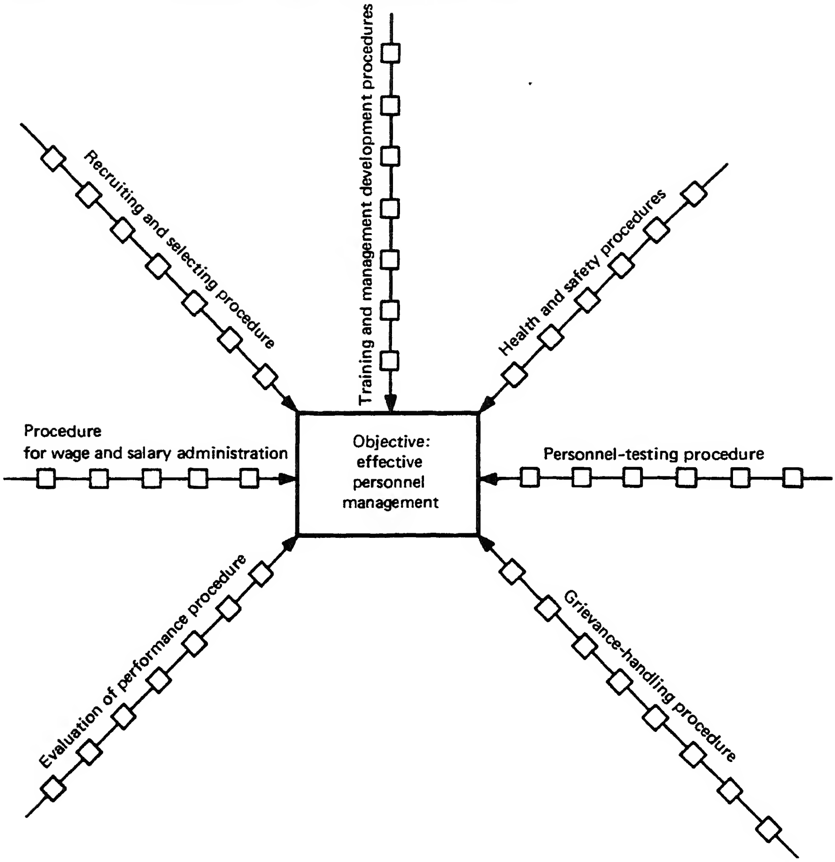
DIFFICULTIES WITH TRADITIONAL SYSTEMS

Traditional business information systems have often been found wanting because they do not provide information with the desired properties mentioned in

[14] You should not despair. Rather, you should fortify yourself with HADACOL (the Hope that Acceptable Definitions will Appear in Computer-Oriented Language). This is an example of an acronym—a term formed from the first letters of related words.

[15] Some writers treat the entire business as a single *system* and the component parts of the business as *subsystems*. In this case our personnel system would be labeled a subsystem within the overall business system. We have no quarrel with this treatment since the difference is primarily one of semantics. Some also treat the entire business as a single information system. When total integration is required, a single system would result from our definition. It should be pointed out, however, that the degree to which information systems (or subsystems) can and should be integrated is rather controversial at this time.

FIGURE 2-2 PERSONNEL INFORMATION SYSTEM



Chapter 1. More specifically, traditional systems often fail in the following respects:

1 *Information is not timely.* Information arrives too late to be of value in planning and making decisions. Therefore the ability to take corrective action to prevent out-of-control situations is hampered. Part of the problem is due to the inability of older systems to cope with increased paperwork loads.

2 *Information is not properly integrated.* Potential users may be unaware of the availability of valuable information produced by internal departments and external sources. The information presented to managers is thus *not as complete as it could be*. As a result, significant past internal relationships are not analyzed; external social, economic, political, and technological factors which influence competitive actions and the business climate are inadequately considered.

3 *Information lacks conciseness.* Too much detail obscures clarity and prevents managers from focusing attention on those areas of significance which deviate from planned performance.

4 *Information is not available in the proper format.* Sales reports may be presented in terms of company departments and divisions when a more valuable classification might be to present the information in terms of products and customers. Report formats often lack consistency. Analyses are frequently presented in monetary terms when another unit of measure might be more appropriate.

5 *Information costs too much to produce.* This is especially true when the information is wanted infrequently and at different times. Optimum use has often not been made of personnel and available data-processing equipment. The financial returns obtained from the information produced frequently does not measure up to returns expected from investment in other areas of the organization.

6 *Information produced is not relevant.* Managers receive information they do not need because they are not in a position to take action which will influence the events reported. And, as noted above, relevant information which would assist the manager in recognizing significant external factors and events is generally not available.

To reduce difficulties experienced with traditional approaches, new systems concepts have been developed. These new concepts are classified into (1) *quick-response systems* and (2) *broader systems.* They are manifestations of rapidly developing computer technology combined with the desire of managers to use this technology to meet increasingly demanding information requirements. It is possible, of course, for a specific business to make use of several of the concepts which will be presented.

QUICK-RESPONSE SYSTEMS

Information is time dependent; it must be collected, manipulated, communicated, stored, retrieved, and presented in a time frame which is appropriate to the problem being considered. Quick-response systems have been developed to increase the timeliness, effectiveness, and availability of business information. *Quick-response systems* have the following advantages:

1 *They allow managers to react more rapidly.* Information from field representatives, customers, suppliers, creditors, and competitors can be more speedily assimilated. Managers may make direct inquiry and promptly receive infrequently needed internal information. And they may "converse" with the system in searching for answers to poorly structured questions.

2 *They reduce waste in the use of business resources.* Waiting time of customers, creditors, suppliers, managers, and employees can be trimmed; more efficient control of valuable and perishable inventories, such as seats on an airplane, can be obtained.

3 *They permit quick follow-up on creative ideas.* For example, by having direct access to a central processor, product research scientists may follow up on ideas which they might otherwise neglect if they had to wait for a long time to use the equipment. Furthermore, it would be possible for them to make quick experiments with different approaches for implementing the idea. Also, programmers may quickly check to see if there are "bugs" in programs or program segments which they are preparing.

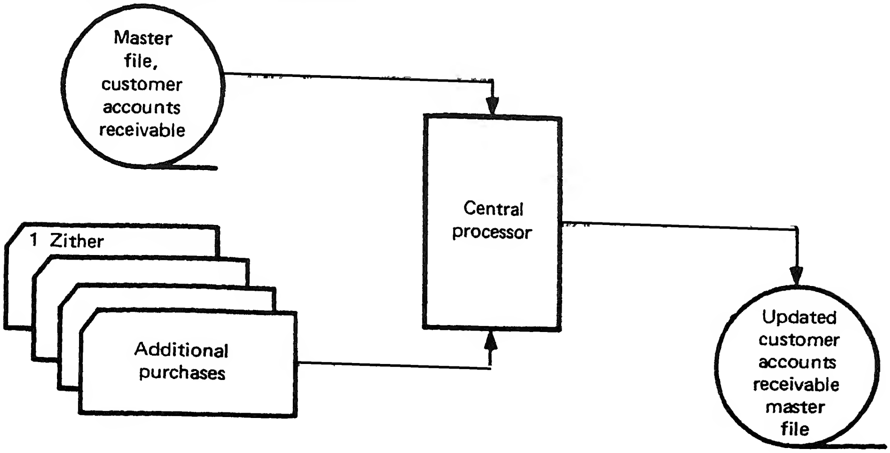
Quick-response systems may be described by a bewildering variety of "Computerese" terms. A glance through a few current management and data-processing periodicals shows the subject to be a veritable semantic jungle with many "experts" swinging from different definition vines. We shall attempt to cut through the foliage by examining the concepts of (1) *online processing*, (2) *real time processing*, and (3) *timesharing*.

ONLINE PROCESSING The term "online" is used in several different ways. We have seen that a peripheral machine connected directly to, and capable of unassisted communication with, the central processor is said to be an online device. Online also describes the status of a person who is communicating directly with (i.e., he has *direct access* to) the central processor without the use of media such as punched cards or magnetic tape. Finally, online refers to a *method of processing data.* However, before looking at the concept of *online processing,* we should pause to describe the characteristics of the *batch-processing* approach.

Batch processing (it is also called *serial, sequential,* or *offline* processing) is the evolutionary predecessor of online methods and accounts for the bulk of the work performed in current installations. Perhaps an illustration will best explain batch methods. Let us trace the activities which follow Zelda Zilch's credit purchase of a zither in a department store. (Zelda also goes under the professional name of Madame Zelda, and her recent fortune-telling windfall has presented her with the opportunity to satisfy a long-standing desire.) The sales slip for this *transaction* is routed to the accounting office where it and others are collected for several days until a large batch accumulates. The data on the slips may be recorded on a machine input medium such as punched cards. The cards are then sorted by customer name or charge-account number into the proper sequence for processing. Processing consists of adding the item description and price of all the recent transactions to the customer's other purchases for the month. Thus, a customer accounts-receivable master file, perhaps in the form of magnetic tape, must be updated to reflect the additional charges. The sequence in which the new transactions are sorted is an ordered one and corresponds to the sequence on the master file. Figure 2-3 illustrates this batch-processing procedure. At the end of the accounting period, the master file is used to prepare the customer statements.

Other files are periodically updated in similar fashion. A *file*, then, is a collection of related records and items treated as a unit. In our example, the

FIGURE 2-3 BATCH PROCESSING



zither purchase was one *item* on Zelda's bill; Zelda's bill would represent one charge-account *record*; and the purchase records of all credit customers would comprise the accounts-receivable *file*.

Batch processing has certain *advantages*:

1 *It is economical.* In general, a large throughput volume results in a low processing cost per record and makes efficient use of computing equipment. Accumulating transactions for large-volume processing permits economies of scale resulting from labor specialization and concentration of effort.

2 *It is the most appropriate method for many types of applications.* In batch processing, transactions are submitted in a group and several results are obtained from processing. This is quite appropriate for important applications such as payroll and the preparation of customer statements. It is not necessary to update employee pay records or to send statements to customers every day. In these examples, the delay brought about by accumulating data into batches does not reduce the value of the information.

On the other hand, batch processing has certain inherent *disadvantages*:

1 *It requires sorting.* Input data and master files must be arranged in some ordered sequence prior to processing. This sorting may be rather expensive in terms of time and money. In addition to sorting, it is also necessary to take time to set up the equipment for each batch job to be processed.

2 *It reduces timeliness in some cases.* The time required to accumulate data into batches, in some instances, destroys much of the value of the data. The information which results from eventual processing is no longer timely.

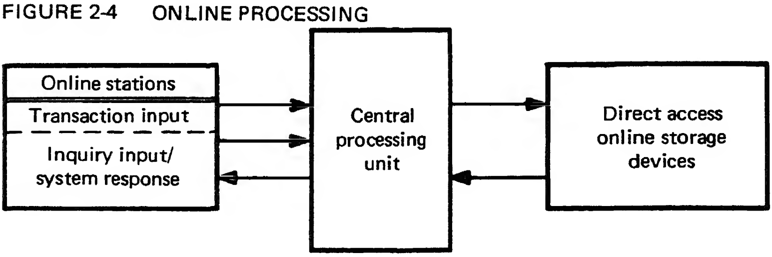
3 *It requires sequential file organization, and this can be a handicap.* To answer inquiries about the current status of the account of Zelda Zilch *between* processing periods is most difficult. If we assume that a magnetic tape master file and an alphabetic sequence are used, Zelda's record will obviously be near the

end of the file and the entire file would have to be searched. Considering the trouble involved and the number of batch jobs waiting to be run, the inquiry might go unanswered until the next processing cycle—and by then, of course, some unwise credit authorizations might have been made.

Online processing has been developed for certain uses as an answer to the batch-processing deficiencies noted above. In contrast to batching, online (or *direct access* or *random access*) processing permits transaction data to be fed under CPU control directly into secondary online storage devices from the point of origin without first being sorted. These data may be keyed in by the use of a typewriter-like terminal, or they may be produced by a variety of other data collection and transaction recording devices. The CPU can make programmed input control checks during this process. Appropriate records (which may be *organized* in the secondary storage unit in either a sequential or random fashion) may therefore be quickly updated. Information contained in any record is accessible to managers without the necessity of a sequential search of the file and within a fraction of a second after the inquiry message has been transmitted. Thus, online processing systems may feature *random* and rapid input of transactions and immediate and *direct access* to record contents as needed. (See Figure 2-4.)

Direct access to records may permit executives to probe and query the file contents of advanced systems in order to ultimately obtain answers to questions which initially were vague and/or poorly defined. The success of such systems will depend upon (1) the availability of a common *data base* (or *data bank*) which will be developed as basic company data are commonly defined and consistently organized throughout the organization and (2) the successful implementation of file-processing software[16] which will "manage" the stored data items and assemble those items needed from the common base in response to the query or instruction of a manager who is not a programming specialist. Direct access to the central processor from an online station may also encourage

FIGURE 2-4 ONLINE PROCESSING



[16] Among the names given by the developers of this type of software are "Data Management System" (Systems Development Corporation), "Data Manager-1" (Auerbach Corporation), "Integrated Data Store" (General Electric Company), and "MARK IV File Management System" (Informatics, Inc.). See the Reading at the end of this chapter entitled "Breakthrough in Management Information Systems" for further discussion of this software.

managers to make more use of the decision-making techniques which will be discussed in the next chapter.

Online processing and direct access to records requires unique hardware and software. For example, the capacity of the primary storage unit of the CPU must be adequate to (1) handle the complex online operating-system executive or master-control program and (2) serve a variety of other storage uses. Also, since many online users may have access to stored records, software security provisions are necessary to (1) prevent confidential information from falling into unauthorized hands and (2) prevent deliberate or accidental tampering with data and program files. Furthermore, in many cases, processors must be fast enough to respond to multiple online stations operating simultaneously in a multiprogramming mode; and large-capacity peripheral online storage units are required to store additional operating-system elements, user data, and programs. Finally, data transmission facilities must be provided to communicate with online terminals located in the next room, on the next block, or thousands of miles away. Data transmission techniques make use of leased or public telegraph and telephone services. The transmission of data over telephone lines is increasing so fast that the American Telephone and Telegraph Company predicts that in 1970 its revenue from long-distance data transmission will *exceed* the revenue received from long-distance voice communication.

It should be noted here, however, that online processing systems may differ considerably in level of complexity. Some systems may have only a few terminals, the volume of transactions to be processed may thus be low; these transactions may be processed on a first-come, first-served basis with no attempt being made to use multiprogramming; and the system may employ relatively simple data-communication facilities. At the other extreme are online systems which have hundreds of remote stations and communication lines; their operating systems may require hundreds of thousands of program instructions; and multiprogramming will be used to interleave the processing of transactions arriving simultaneously from a number of stations.

The speed of processing needed by a business varies with the particular application. As we have seen, batch processing is appropriate for many jobs. Online processing, although faster than traditional methods, may involve different degrees of quickness in the needed response. For example, a system may combine immediate access to records for inquiry purposes with *periodic* (perhaps daily) transaction input and updating of records from a central collecting source. Such a system would meet many needs and would be simpler and less expensive than an online, real time system.

REAL TIME PROCESSING The words "real time" represent a semantic bucket of worms—you can choose from over 30 definitions which have appeared in the literature. (This has led a few authorities to recommend that the words be dropped altogether.) Some writers maintain that a system is responding in real time if it furnishes information to a manager in time for him to take effective

action. Using this definition, a manual processing system might be operating in real time for some applications. The consensus of opinion is, however, that a *real time processing* operation is (1) in a parallel time relationship with an ongoing activity and (2) producing information quickly enough to be useful in controlling this current live and dynamic activity. Thus, we shall use the words "real time" to describe an online processing system with severe time limitations. A real time system is generally considered to be online; an online processing system, however, *need not* be operating in real time.

Real time processing requires immediate (not periodic) transaction input from all input-originating terminals. Many remote stations may be tied directly by high-speed communications equipment into the central processor; several stations may be operating simultaneously. Files may be updated each minute, and inquiries may be answered by split-second access to up-to-the-minute records. Systems of this type which extend beyond company boundaries are used by airlines to control the inventory of airplane seats available. Other examples of business real time processing are the systems designed to keep track of the availability of motel and hotel rooms (e.g., the system of the Holiday Inn chain), the systems which provide for immediate updating of customer records in savings banks, and the systems which provide up-to-the-minute information on stock prices.

Real time processing is required and cooperation is necessary among airlines because of the perishability of the service sold—when an airplane takes off, vacant seats have no value until the next landing. It would be a mistake, however, to assume that real time processing should be universally applied to all data-processing applications. A quick response system can be designed to fit the needs of the business. Some applications can be processed on a lower priority or "background" basis using batch methods (e.g., payroll); some can be online with periodic (not immediate) updating of records; and some can utilize real time methods.

TIMESHARING Timesharing has always existed in computer installations in the sense that different departments in a company shared the total time of the hardware by requesting and receiving processed information. Generally, the jobs to be run for these departments receive a priority rating and a job queue develops. Low-priority jobs may not be completed for days. In the quick response context, however, there is a much shorter time scale involved. We have just seen that real time processing permits the sharing of system resources among many online stations.

Timesharing is a term used to describe a processing system with a number of independent, relatively low-speed, online, *simultaneously usable* stations. Each station provides direct access to the central processor. The speed of the system and the use of multiprogramming allows the central processor to switch from one using station to another and to do a part of each job in the allocated "time

slice" until the work is completed. The speed is frequently such that the user has the illusion that he alone is using the computer. Timesharing systems vary from those which are designed for special purposes by a single organization (e.g., an airline reservation system) to those which are intended to provide services to a multitude of different organizations seeking to process a broad range of business and scientific jobs. Much of the contemporary literature dealing with time-sharing emphasizes the latter type of system.

The number of special-purpose timesharing systems is growing. More dramatic, however, is the growth of general-purpose, multisubscriber installations which have been established to service the needs of different organizations. In contrast to the typical arrangements made with a commercial computer center (which usually assumes the responsibility for performing a task), the control of processing in a timesharing operation generally remains with the using business. Transactions are initiated from, and output is delivered to, the premises of the using firm at electronic speeds. The subscriber pays for the processing service in much the same way he pays for his telephone service: There is an initial installation charge; there are certain basic monthly charges; and, perhaps largest of all, there are transaction charges (like long-distance calls) which vary according to usage.

Because of similarities with public utilities (such as telephone companies), such timesharing services have been called *information utilities* and *computing utilities* to the chagrin of industry spokesmen who feel the term "utility" suggests monopoly power and invites unwanted governmental regulation. The first completely commercial information utility was dedicated in November, 1965, in Cambridge, Massachusetts. Founded by Charles W. Adams, a former M.I.T. professor, Keydata Corporation was providing quick-response online service to 30 subscribers and 60 stations within a year. At least one subscriber replaced its own computer with the service. At the beginning of 1968, there were less than 50 general-purpose timesharing installations in the United States. It has been estimated, however, that there will be 1,000 timesharing systems operating by 1971.[17]

The following *advantages of timesharing* help explain its expected rapid growth:

1 *Timesharing can reduce central processor "idle time."* It is wasteful (and expensive) for the CPU to be effectively utilized less than 30 percent of the time. Yet this is what happens in a conventional batch-processing installation as the CPU waits during set-up times and during input/output operations. Timesharing can significantly increase CPU utilization.

2 *Timesharing offers computing capability to small users.* Small businesses can gain direct access to much more sophisticated hardware and software than they

[17]See James Glauthier, "Computer Time Sharing: Its Origins and Development," *Computers and Automation,* pp. 23-26, October, 1967.

could otherwise justify or afford. They merely pay a fee for resources used and are relieved of the problems associated with acquiring and maintaining their own installations.

3 *Timesharing can provide the quick-response advantages noted earlier.* It allows managers to react more rapidly; furthermore, it permits them to interact or converse with the system in seeking solutions to unusual problems and answers to poorly defined questions. Timesharing may also reduce waste in the use of business resources, and it can permit quick follow-up on creative ideas.

4 *Timesharing can improve input accuracy.* Inserting data into a file as they are originated eliminates errors which might occur during keypunching, sorting, etc. Also, programmed checks can verify the reasonableness of input data before they are accepted.

5 *Timesharing can reduce the output of paper.* If a manager can retrieve at any time the specific information he needs from an online file, he does not need a bulky report which contains much of the file information.

But the following *timesharing problems remain to be considered:*

1 *The question of economics* From a strict cost standpoint, a small firm with enough batch-processing volume to use about two days a week of computer time would likely find it less expensive at this time to acquire its own small in-house installation.[18]

2 *The problems of data communications* The *cost* of data communication has been declining, but not nearly so rapidly as the cost of processing data. Thus, data transmission charges make up an increasing portion of the total timesharing cost package. In addition, telephone lines were designed for voice communication rather than data communication, with the result that current transmission equipment is not considered adequate by many timesharing spokesmen. For example, a severe mismatch often exists between computer speed and the slower capabilities of the locally available transmission equipment. Furthermore, some types of message switching equipment have generally proven to be too "noisy" to handle data transmission. The line noise may change the meaning of a character as far as the computer is concerned, or it may be interpreted as a character where none was intended—an unsettling thought! Finally, common carriers object to "foreign attachments" being connected to their lines. Computer spokesmen maintain that carrier equipment isn't satisfactory and that other available equipment would do the job better if the carriers would just permit its use.

3 *The uncertainty of regulation* At the time of this writing, the Federal Communications Commission is conducting an inquiry to determine whether data transmission facilities and services are compatible with the needs of timesharing users. The FCC is also looking at (a) the regulated charges levied for

[18]See David H. Li, *Accounting/Computers/Management Information Systems,* McGraw-Hill Book Company, New York, 1968, p. 281.

data transmission service by the common carriers, (*b*) the nonregulated charges of information utilities, (*c*) the question of whether additional or less government regulation is needed in this area, and (*d*) the question of the need to ensure data privacy.

4 *The question of security* Provision must be made to protect the security and integrity of user data and programs maintained in online storage. This is currently being accomplished by such methods as (*a*) assigning certain areas of storage to only one user and to only his terminals, and (*b*) requiring hierarchies of passwords or lockwords from users prior to file access. In spite of such precautions, however, some authorities believe that a knowledgeable system programmer could, if he desired, bypass programmed controls. If so, the question of security will require much greater study.

5 *The problem of reliability* There will be less margin for equipment downtime as more users come to rely on timeshared services. Provisions will have to be made to provide dependable and continuous service.

The quick-response system concepts which we have now considered are improving the timeliness, effectiveness, and availability of information. In addition, many of these emerging quick-response systems are taking a broader approach to the needs of the firm by attempting to provide better integration of information-producing activities. In the following section we shall briefly examine this trend.

BROADER SYSTEMS

Better integration of information-producing activities can lead to information which is more complete and relevant. Traditionally, business data processing has been organized by departments and by applications. Many computers were originally installed to process a large-volume job such as payroll or customer billing. Other applications, treated independently, followed, but it soon became clear that this approach was unsatisfactory. In some cases, basic company data were defined and organized differently for each application; thus, the data were often expensively duplicated (with an increase in the possibility of error) because it was impossible to integrate these facts in meaningful ways. For example, information from the payroll file and the personnel file could not be combined because of different methods of classifying employees.

Dissatisfied with such conditions, some businesses began looking for ways to consolidate activities. Various names are given to these efforts. Among the terms used are (1) *integrated systems*, (2) *single-flow or data-bank systems*, and (3) *total systems*.

INTEGRATED SYSTEMS Integrated systems have as their objective the single recording of basic data into a common classifying code for the purpose of making maximum use of the data with a minimum number of human operations.

A common example of this approach is found in the handling of sales orders. An order is received and confirmed on a special typewriter which produces a punched paper tape as a by-product. The sales data (customer name, address, items ordered, etc.) are punched on this tape, which may then be used as a computer input to prepare shipping orders and the customer invoice. The same data are also used to update inventory, product sales, and accounts-receivable files. Obviously, the same common classifying code must be used to represent the data in the several files.

SINGLE-FLOW SYSTEMS AND DATA BANKS Single-flow systems are designed around a *single* integrated information file or *data bank*. This file is located in directly accessible online storage. Transactions are introduced into the system only once; all data-bank records that these transactions affect are updated at the time of input. The total file is not subdivided into applications. The single-flow concept requires that input data be commonly defined and consistently organized and presented throughout the business. And this requirement, in turn, calls for rigid input discipline; it also means that someone in the organization must be given the overall authority to standardize (and approve any necessary changes to) data with companywide usefulness, such as part numbers and customer and employee identification codes, in order to ensure that inconsistencies in data definitions are not introduced into the system.[19] As noted earlier, such a data base, combined with the successful implementation of data-management software[20] which will organize, process, and present the necessary data elements, will enable managers to probe and query file contents in order to extract the needed information.

In addition to having direct access to data generated within the organization, a manager may also have externally produced information at his fingertips. It is anticipated that the sale of raw data will grow rapidly in the future. Such data will be produced by the data supplier's computer in a form to be used as input by the customer's system. Of course, this will necessitate an agreement on data format if effective use of purchased data is to be obtained. Industry data standards will develop because of this fact. In the future, firms may have to decide whether to "make" their own data or "buy" them from external data banks, just as they have often had to make similar decisions about physical

[19] Victor Brink, a Columbia professor, believes that although a closely integrated system might not now be planned, it is important for firms to begin now to achieve this standardization so that at a later time they will have the *option* of introducing broader systems. See "How the Computer is Changing Management Organization," *Business Management*, p. 28, July, 1967.

[20] For a discussion of such software, see Dr. Paul Kircher's article at the end of this chapter. Also, see Robert V. Head's discussion of information management systems in the reading entitled "Management Information Systems: A Critical Appraisal" (last reading in this chapter).

products.[21] Examples of data currently being sold in machine-sensible form include:

1 *Marketing data* Data about products sold in its stores are available from the Kroger Company; *Sales Management* magazine provides information on income and consumption patterns by geographic area; and the F.W. Dodge Company, a McGraw-Hill subsidiary, sells data about the construction market.
2 *Financial data* Dun and Bradstreet provides a financial file on over 300,000 firms; another McGraw-Hill subsidiary, Standard & Poor, offers a COMPUSTAT file which contains sales and earnings figures on about 2,500 companies.
3 *Economic data* Economic statistics are available from a number of government agencies including the Bureau of the Census and the Department of Commerce.

User response to the wealth of statistics made available by the government has been good, but it has touched off a significant—and as yet unresolved—controversy. Late in 1966, after eleven months of study, a special government Task Force on the Storage of and Access to Government Statistics, recommended to the Bureau of the Budget that a National Data Center be established. This center would consolidate all data compiled by about twenty federal agencies. Budget Bureau officials maintain that such a center would lead to more effective economic and social analyses by (1) improving the comparability of interrelated statistical data, and (2) making these data more readily available. In spite of the merits which such a data bank might have, a number of opponents are concerned about the threat which it might eventually present to an individual's right of privacy. Given the current state of the art, they say, what is to prevent an unauthorized party from gaining access to confidential personal information?[22] What guarantees will the individual have that the information contained in his dossier is accurate and complete? Might not such a data bank be the beginning of a drift toward George Orwell's *1984*? Such questions deserve the serious consideration they are currently receiving.

TOTAL SYSTEMS Although the term "total systems" has been used in so many ways that it is now too ambiguous to be of much value, it has been described as the ultimate result of the consolidation of integrated subsystems. Thus, the words have been used to describe a single information system—a "total" system—which makes use of quick-response tools and techniques such as online mass storage, immediate updating of records from remote stations, and online inquiry.

[21] This statement also applies to software.

[22] Fred Gruenberger has described, in fascinating detail, how it is that a programmer may not be sure of the consequences of what he has programmed. He notes that it is impossible to assume that any network is secure, particularly if it utilizes telephone lines. See "The Unpredictable Computer," *Datamation*, vol. 13, pp. 59ff., March, 1967.

"Most systems analysts and corporate managers who talk about and aspire to 'total' information systems realize that the ideal may be extremely difficult if not impossible to achieve."[23] It is not at all clear to what extent systems should be broadened. As a *philosophy*, however, the total systems concept has made a contribution. Computers *do* make certain consolidations possible; most of the older systems *were* too narrow. Many businesses are now working toward gradual integration of information-producing systems[24] and toward the creation of data banks. The approach is generally somewhat conservative because (1) broad studies take a long time, are quite complex, require the efforts of highly paid employees who are in short supply, and often do not show any prospect of immediate tangible benefits; (2) substantial gains are still possible by placing new applications on the computer; (3) resistance is often encountered from managers who do not want to experiment with the familiar system; and (4) the planning and coordination of such a study is complicated, since in many cases no single individual can really understand the total system.

The above pages have shown some of the revolutionary developments in technology and in the uses of this technology which have occurred since 1960. The rate of change in the future will be compounded by the changes made yesterday and today. The full potential of the computer has yet to be realized by businesses, but several are now in the process of moving out of a period of learning (though learning, of course, continues) into a period of innovation.

DISCUSSION QUESTIONS

1 Discuss this statement: "The basic challenge to the managers of today is to foresee and manage (and not be swept along by) the flood of changes facing their organizations, within a democratic framework, for the benefit of society as well as for the benefit of customers, employees, and owners."

2 (a) Describe several of the scientific discoveries which have been made since the beginning of World War II.
  (b) Comment on the broadening scope of scientific inquiry and on the rate with which new knowledge is put to use.
  (c) What effects do scientific changes have on business management?

3 (a) Identify and discuss the social and economic changes which are taking place today.
  (b) What effects will these changes have on business management?

[23] Peter A. Firmin and James J. Linn, "Information Systems and Managerial Accounting," *The Accounting Review*, vol. 43, p. 76, January, 1968.

[24] See the section on systems integration in the reading at the end of Chap. 3 entitled "The Computer Comes of Age."

4 Discuss this statement: "To compete profitably in the future, a manager must have information of the highest quality."

5 (a) What changes have taken place in computer hardware?
  (b) In computer software?

6 (a) What are the three basic software categories?
  (b) Discuss the developments in each of these categories.

7 What functions are performed by operating systems?

8 Describe the effects of computer hardware and software on
  (a) the market for computers, and
  (b) the demand for computer specialists.

9 (a) What are business information systems?
  (b) What is a procedure?
  (c) A method?

10 What difficulties have managers experienced with traditional business information systems?

11 (a) Why have quick-response systems been developed?
  (b) What are the advantages of such systems?
  (c) What is the distinction between online processing and real time processing?

12 (a) What is batch processing?
  (b) How does it differ from online processing?
  (c) What are the advantages and disadvantages of batch processing?

13 "Online processing and direct access to records requires unique hardware and software." Discuss this statement.

14 (a) What is meant by timesharing?
  (b) What is an "information utility"?
  (c) What are some of the advantages and current limitations of timesharing?

15 Identify and discuss the broader systems approaches which have been used to consolidate information-processing activities.

CHAPTER TWO READINGS

INTRODUCTION TO READINGS 5 THROUGH 10

5 In this reading George Glaser reviews computer technological developments and discusses the shortage of technical personnel. It is pointed out that because of new developments in computer technology, applications will be extended from processing paperwork to improving management's decisions. But although new applications promise greater benefits, they also create personnel problems, are harder to justify on a straightforward cost-saving basis, are more difficult to design, and are more painful for the organization to assimilate. Thus, computer feasibility must be determined by careful analysis.

6 After describing what a management information system should do, Robert Beyer then (1) examines some of the current trends in systems development, (2) shows how systems are serving top management in a variety of settings, and (3) provides some guidelines for information systems design.

7 Brandt R. Allen provides in this reading a general orientation to computer timesharing services. After presenting an example of the ease of communicating with a timeshared computer, Professor Allen discusses (1) the reasons for the rapid growth of timesharing, (2) the ways in which timesharing is being used by businesses, (3) the likely future developments in timesharing services, and (4) the factors to consider in selecting a service.

8 The President of Time Share Corporation notes here the use of timesharing in such areas as financial analysis and hospital administration. The future educational impact of timesharing is considered, and future hardware and software developments which promise to add impetus to the timesharing movement are also discussed.

9 This reading deals with the subject of file-processing software. "Data management," "file management," and "information management" are terms used to describe such programs. As you will recall, this software manages the stored data and assembles the data items needed from a common base in response to inquiries from managers. Professor Kircher identifies several file management approaches and explains how a manager might use file management software.

10 This is an appropriate reading to use to conclude the subject of the information-processing revolution. After discussing some of the basic concepts and design objectives of management information systems, Robert V. Head comments on the approaches being taken by large organizations which he believes best characterize contemporary information systems development. There is also a brief discussion of some of the current problems in the volatile

ld of information systems. Such problems are often not of a technical nature; ther, they are problems which carry important managerial implications. In the xt chapter we shall look at several managerial implications of computer usage.

EADING 5 PLAIN TALK ABOUT COMPUTERS*

EORGE GLASER

decade or so ago, at the dawn of the computer era, writers of Sunday pplement articles were fond of describing the mysterious new electronic dget as a superbrain possessed of nearly magical powers. More recently it has come fashionable to point out, rather disparagingly, that the computer can do ly what it is programmed to do. This sounds a lot more sophisticated, but it isses a crucial point. In the words of Herbert Simon, the observation that the mputer can only follow instructions is "intuitively obvious, indubitably true, d supports none of the implications that are drawn from it." [In *The Shape of utomation* (New York: Harper & Row, Publishers, 1965).] For the fact is that e computer's capabilities, though not supernatural, far exceed any use yet ade of them.

The computer is, first of all, a dutiful and tireless slave in processing huge lumes of paper work—subscriber billing, insurance premium accounting, credit rd invoicing, and on and on. Second, it can deal with problems of mplexity—problems that are literally insoluble, in any practical sense, by anual methods. Typical problems of complexity are satellite tracking and pact prediction, economic models for long-range corporate planning, and timization of petroleum refineries. Third, the computer can provide extremely pid response to external events. This capability of the computer, a relatively cent development, has led to airline reservation systems, on-line monitoring of spital patients, process control (in the petroleum, paper, and chemical dustries, for example), and most important, perhaps, to time-sharing and the uch-discussed computer public utility.

ECHNOLOGICAL DEVELOPMENTS

lost of these applications would have taxed our imagination ten years ago. oday we accept many of them as routine. And we see a continuing series of

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new developments in computer technology—both hardware and software—that opens up entirely new horizons to us.

Massive files, storing hundreds of millions of characters of data and retrieving them in millionths of a second, are being installed. Only months ago a computer manufacturer announced a memory device that will allow storage densities of one million bits per square inch, approximately the amount of information on six pages of a four-column telephone directory. For some time we have had photographic techniques that would reduce these six pages to one square inch of film, but the data stored using the new technique can be retrieved, manipulated, and stored again. This new capability is only one of many developments now being explored.

Computer memory specifications are no longer stated in microseconds but in nanoseconds. A nanosecond—one billionth of a second— is a difficult figure to comprehend, but try this: There are as many nanoseconds in one second as there are seconds in thirty years, or as many nanoseconds in 2.5 seconds as there are seconds in a person's lifetime.

These changes in the internal workings of the computer are difficult to understand and appreciate. More obvious changes are occurring in input/output equipment; these changes for the most part are intended to increase human access to the machine. We see increased use of graphic techniques for all kinds of engineering applications. The automobile industry is using graphic display systems to design cars; the aerospace industry is using them for aeronautical engineering and for shortening the production lead times of new types of aircraft.

Communication capabilities now allow the computer to switch both data and normal message traffic. In the planning stage are public computing utilities that will provide access to computing power over communication circuits by widely dispersed users, each paying only a fraction of the system's cost. A single computer now can handle multiple programs, processing several independent applications at the same time. This development has led to the introduction of time-sharing systems. Forty or more users in as many different companies may each sit at a typewriter-like console connected by teletype or telephone to a computer located miles, or thousands of miles, away. The computer's response time is so fantastically quick that it can serve forty masters at once without strain. For each user, it is precisely as if he alone had sole and complete access to the computer. For all practical purposes, he does.

COST TRENDS

Despite these fantastic increases in the power and complexity of hardware, hardware costs are falling. In the past few years, they have declined from 50 to 40 per cent of the total cost of a typical data processing installation. With further

progress in low-cost mass storage and high-speed microcircuitry, indications are that the trend will continue. Cost-performance curves show a steady improvement in output per dollar, and no leveling-out is in sight.

Software and applications development costs, on the other hand, have continued to rise despite the best efforts of equipment manufacturers and software houses to develop higher-level languages. These efforts, for the most part successful, have greatly eased the burden of the programmer in translating systems logic into operating instructions for the computer, but they have not reversed the upward trend of costs. There are two reasons for this. First, the systems themselves are more complex, span larger portions of the business enterprise, and thus increase the difficulty of analysis and design. Second, the severe shortage of experienced systems design and programming personnel has rapidly driven up their salary levels.

PERSONNEL TRENDS

In terms of immediate practical effects, people—not technological trends—are the overriding issue of tomorrow. Already the supply of talented programmers and systems analysts is far short of the demand, and the gap is widening inexorably. For the foreseeable future, there is literally no possibility that we shall have enough trained people to go around. All three categories of special skills needed to use the computer effectively are in short supply:

1 *Operations researchers and management scientists*, who apply mathematical and statistical techniques directly to the problems the decision maker faces and to the information he needs to run his business. They also must determine the means for providing management with the best alternatives on which to make decisions.
2 *Systems analysts*, who design the complex mechanisms for applying the computer to the detailed activities of the entire operation.
3 *Computer programmers*, who translate the work of the operations research and systems analysts into the language of the computer.

There are somewhat more than 100,000 qualified computer specialists in America today. By the end of 1970, roughly 300,000 will be needed—an increment of well over 50,000 each year between now and then. Quite obviously, this is not going to happen. Alarmingly, however, company managements are acting and thinking exactly as if it were.

We asked a few leading computer users to compare the number of computer personnel on their staffs in 1965 with the number they had employed in 1960 and with their anticipated requirements for 1970. In aggregate, these companies had more than tripled their computer staffs between 1960 and 1965. Between 1965 and 1970, they were planning an increase of another 50 per cent.

In this sample, the company with the longest computer history and the largest

and slowest-growing staff will have recorded a personnel increase of 200 per cent from 1960 to 1970. By way of contrast, two companies that did not become active computer users until 1960 have increased their staffs since then by ten times and fourteen times, respectively, and will have increased them by about twenty times by 1970—*if* their present plans are realized. Clearly, a five-year-old company computer effort has not yet come of age. Observation suggests, in fact, that maturity and stability seldom come until about the ten-year mark.

The scramble for skilled computer personnel in private industry will be seriously aggravated by competition from federal, state, and local governments, whose rate of growth in computer activity almost certainly will exceed that of private industry in the next few years. This, of course, means a further intensification of demand for trained OR specialists, systems analysts, and programmers in the biggest business of all.

Clearly, the competition for talented people is going to get fiercer—and management's use of computer systems five years hence will probably be seriously hobbled by a lack of competent people to analyze applications and program their machines. Companies leading the field today will, in all probability, continue to attract the best people available, thereby extending their lead. The rich, in other words, will get richer, while the company attempting to build an organization from scratch will find itself at a very serious disadvantage—not least because it will have trouble convincing high-talent people that it is a progressive company to work for.

The frustration of being unable to find and hold enough qualified specialists to develop needed systems will almost surely impel many companies to pressure their operating executives into taking an important hand in systems design and development. Yet, the more complex the new applications become, the dimmer is the hope of salvation offered by this alternative. To see why, let us look at the nature of some of the changes now occurring.

APPLICATIONS

In just a few years, the nature of computer applications has changed dramatically. In most companies, the first applications were designed to process routine transactions, mostly in accounting. Here the computer proved itself a swift, accurate, and insatiable processor of mountains of paper work. In many cases, clear-cut savings were achieved by reduction of clerical costs. These routine applications could be justified economically by relatively straightforward extensions of known cost factors, and apart from some procedural adjustments, little in the company had to change.

The next era of computer applications saw the rise of business systems for inventory control, production scheduling, cash management, and the like. At the time these applications were designed and implemented, they were considered

very complex. Their designers took considerable pride in making them work—and a few resounding fiascoes resulted. But, in general, these systems brought about lower inventory levels, faster deliveries to customers, and smoother production. Their benefits, however, were harder to estimate. On occasion, management authorized these efforts without any guarantee of dollar results appearing on the profit-and-loss statement.

Significantly, companies began to realize that these more complex systems could raise sticky issues of corporate policy. What, for example, is the objective of inventory control: reduced working capital, improved customer service, or lower production costs? Can all these objectives be satisfied at once? Top executives had to help answer such questions. It became apparent that computer systems were introducing a new dimension of difficulty. Close coordination of the individual requirements of several functional and staff departments had become necessary.

Today, with increased hardware and software capabilities, we see opportunities for tackling still more important business problems on a still higher level of complexity. Our new goal is the most ambitious yet: to improve management's decisions. In terms of potential benefits—better planning, better allocation of resources, more timely decisions, explicit consideration of risk and uncertainty —these systems offer an economic potential far greater than the most successful paper-work processing applications of just a few years ago. But they are far harder to justify on a straightforward cost-saving basis, far more difficult to design, and far more painful for the organization and its people to assimilate.

Management information systems (especially the "total" or "integrated" variety) are currently much in vogue. The ultimate objective of such a system, in grossly oversimplified terms, is to collect all the data pertaining to a company's operations and to amass it in vast computer files from which any information and all reports can be readily extracted. Of course, only a few zealots would seek to realize this objective literally. More practical systems designers realize that it would be technically impossible and economically untenable to collect *all* the relevant data. Their approach is to integrate certain closely related functions of the business—inventory control and production scheduling in a manufacturing company, for example. Such systems are now being designed, but not even the most expert of systems analysts would argue that they all offer clear sailing.

By definition, a system consists of interrelated parts functioning together toward a single goal or objective. A television set is a system that receives a signal, processes it, and displays a picture; similarly, an automobile ignition system responds to a signal and delivers electrical energy to the spark plugs. Such electrical and mechanical systems have a completely unambiguous objective; their design is single-purpose and they are relatively reliable. We are not so blessed in the case of business systems. Business systems involve people—and people, with their individual designs and conflicting objectives, are of questionable reliability from the systems designer's point of view.

Most of the functioning computer systems today were designed for a single purpose; in many cases, they served only a single user department. Their design and implementation, accordingly, posed relatively few problems. Now, however, we are designing systems that affect entire organizations; every operating function of the business will be part of the information system needed to control it. And, since systems are characteristically susceptible to the failure of their weakest link, a management information system may be crippled or wrecked if just one operating manager providing data to the system does his job poorly.

It would seem that the applications now confront us with an entirely new level of difficulty. First, the technical problems are considerably more difficult, a point that can easily be confirmed by asking any data processing manager how many of his people are qualified to modify the operating system that controls the flow of programs through third-generation computers. Second, it is becoming increasingly difficult to estimate the expected benefits as problems deal more and more with factors that cannot be quantified in advance. Third, the new applications require far more organizational discipline and coordination than did the earlier single-purpose systems.

FEASIBILITY

A data processing project should be considered an investment; benefits are expected, costs will be incurred, and risks are involved. On the basis of an evaluation of these costs, benefits, and risks, the company allocates resources of manpower, equipment, and time to specific projects. In principle, this approach is not very different from any other investment of resources, but in practice a computer systems proposal poses special complexities that call for detailed analysis. This analysis is usually conducted as part of a feasibility study.

Three aspects of feasibility—technical, economic, and operational—should be evaluated in a feasibility study. They deal, respectively, with (1) whether the project can be implemented, given existing constraints on known technology and the company's ability to exploit it; (2) whether the economic benefits will outweigh the costs, and whether they represent the best available return for the resource investment; and (3) whether the implemented system will function successfully in the given environment.

Technical feasibility, primarily the province of the computer systems staff, involves defining alternative approaches to the problem and specifying the technical resources each approach will require. Given today's advanced equipment and software, few business systems are likely to prove technically impossible, but their feasibility, in terms of available corporate resources, often cannot by any means be taken for granted. And the "best" technical approach can seldom be identified without imaginative and painstaking systems analysis.

Economic feasibility cannot be determined by the systems staff alone. To be sure, they can and should weigh the economic benefits of the proposed system, as estimated by the line managers for whom it would be developed, against predictable development and operating costs. But these calculations, although necessary, are not sufficient—the same resources invested in a different project might have produced a greater return. Assessment of the opportunity cost of a particular application is the key to the question of economic feasibility.

Operational feasibility, though seldom formally evaluated, is no less important. Because the constraints on operational feasibility are motivational and organizational, they frequently are overlooked by managers and technicians alike.

Computer systems do not operate in a vacuum; they serve and are served by people. Unless the people involved are sold on the system, want to make it work, and are eager for the help it can give them, its technical and economic feasibility are simply irrelevant. The necessary motivation, in turn, depends on whether the system will enable the people affected to perform better in ways that are rewarded by the company's established value system. The most detailed computer-aided sales analysis and reporting system, for example, will fail to achieve its objective of concentrating salesmen's attention on profitable accounts and lines if their compensation plan continues to reward them solely on the basis of volume.

Again, how enthusiastic will the head of one department be about incurring additional costs to supply another department with data that will enable it to make a significant added contribution to over-all company profits? The answer depends entirely on how Department A's performance is evaluated.

If the sole yardstick is control of departmental expense—if, in other words, the responsible executive is paid to be myopic about matters outside his immediate authority—his department may well prove to be the reef on which the entire project goes aground.

Only top management is really in a position to insure operational feasibility. The analysis need not be formal, but it had better be thoughtful and thorough, for the pitfalls in this area are many—and some are far from obvious.

WHAT THE MANAGER CAN DO

No set of rules will guarantee success with any undertaking as complex as a corporate computer systems effort, but a few guidelines for the individual can be formulated.

1 He should identify how his job is related to the objectives of the company. This obligation, of course, applies to every manager, quite apart from any consideration of the computer effort. But it applies with singular force to the manager whose company is pushing ahead into strategic applications of the computer.

2 He should consider how the computer can contribute to performance in working toward these objectives. In doing so, he should seek the help of the data processing department. If the manager identifies an opportunity to use the computer, he must be willing to put a value on it—but not to confine his research to applications that will generate a measurable dollar return, in reduced clerical costs, for example. Even if these applications develop as anticipated, the effort may consume valuable developmental resources that would be better spent on projects of more strategic significance.
3 He should insist on helping to design the system and on approving the costs/benefit trade-offs—shorter development time vs. better system performance, for example. Such trade-offs arise in any major system development, and since the data processing staff cannot really evaluate potential benefits, they should not be compelled or permitted to make the trade-off decisions.
4 He should encourage his people to use installed systems well. If a system does not work as it should, he should recommend changes. The manager can complain if he does not like the results, but he is not to carp; if the system does not live up to expectations, it may be his fault. He, after all, is an integral part of any system he uses.
5 Finally, he should agree to an audit of the results after systems are installed. This aspect is most important in systems development. It will help not only the manager but the data processing department to do a better job the next time.

The computer is synonymous with change—changes in the way business is conducted, in its internal organization, and in the decision prerogatives of its managers. Those companies, and those managers, who have the ability to accept and take advantage of change generally use the computer well and find it a powerful and profitable adjunct to their operations. Those who shrink from change and revere the *status quo* generally find it difficult to absorb the computer's impact on their operations.

The computer requires more than toleration, or the attitude that "it's here to stay and we may as well learn to live with it." Companies that are living with the computer begrudgingly are usually unhappy with the results, and will be for a long time. The computer is a mechanical beast, and its master, the human, is a fantastically complex and wonderful creature possessed of powers to think, reason, judge, and feel. So if an intelligent human being decides to scuttle the computer, it is generally no contest. A good systems designer tries to make his system not only foolproof but *idiot*-proof, since the odds are that the system will, in fact, have to ward off a few attacks by idiots. But this kind of preventive is not enough. The company that expects to use the computer effectively must not only accept change, but reach out and grasp it. And managers—not technicians or hardware—will determine its success.

READING 5 DISCUSSION QUESTIONS

1 (a) Why have software and applications-development costs continued to rise as hardware cost/performance curves continue to improve?
   (b) What factors contribute to the shortage of computer personnel?
2 "A management information system may be crippled or wrecked if just one operating manager providing data to the system does his job poorly." What are the implications of this statement?
3 (a) What is meant by technical feasibility?
   (b) By operational feasibility?
   (c) By economic feasibility?
4 How can a manager help improve the chances for success in computer systems development?

READING 6 A POSITIVE LOOK AT MANAGEMENT INFORMATION SYSTEMS*

ROBERT BEYER

The phrase "management information systems" is among the most used—and abused—in industry today. In recent years it has been applied to virtually every kind of computer application, ranging from pure payroll processing to closed-cycle control of production machines. As a result, it is frequently misunderstood and often unjustly criticized.

The controversy has resulted in part from differences in nomenclature and in part from the variety of opinions on how management information systems can or should be applied to management problems and when they will be universally adopted. But the main source of confusion lies in the lack of a consensus on what management information systems are supposed to be and how they should be designed to meet the growing needs of management today.

Lest we become lost in the miasma of speculation and expensive false starts, we must return to fundamentals and try to develop a fresh perspective on management information systems, unobscured by the magnification of "nuts and bolts."

The movement toward more fully integrated systems is already underway and will not be retarded by unresolved questions, however legitimate. This movement is evidenced by the growing number of major U.S. concerns that have already installed centralized management information systems or are planning to

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do so. Moreover, as management is subjected to increasing pressure for faster, more complete, and more fully coordinated information, it is only reasonable to assume that the trend must gain momentum, especially with the advent of the third generation computer.

These rather general statements, of course, do nothing to dispel the confusion and misconceptions that have arisen in some quarters. The objectives of this article, therefore, are first to define more clearly a management information system; second, to examine some of the current trends in system development; third, to show how systems are serving top management in a variety of settings; and, finally, to provide some guidelines for information system design.

The explosive growth of the data processing industry during the last 20 years has created many language problems. What is called a "compiler" by one company may be an "assembler" to another. What is "automation" for one firm is "process control" for the next. What is "on-line" in one environment is "off-line" in another. What is "real-time" in many areas represents nothing at all in others.

Despite differences in nomenclature, it is possible to define a management information system in terms of what it should do rather than in terms of what it is. Once this point is established, we can see what effect modifiers such as "total," "integrated," etc., have on its meaning.

The *raison d'etre* for any information system should be a need to know. While payroll records in a large organization constitute information, there is no need for top management to know that a particular man accumulated six hours of overtime in a given week. On the other hand, if a particular manufacturing section should happen to go 15 per cent over its budget for the week, the appropriate top-level manager should be informed. The more timely and accurate the information presented to the manager, the better equipped he will be to take whatever action is necessary.

Around the turn of the century the need for information could be satisfied in a most elementary fashion. In a typical system, data acquisition and processing was achieved by jamming an invoice or bill onto a spindle, payables to the left and receivables to the right. Recording this information in a central data storage bank meant, quite simply, copying it into a ledger book. The ledger book was usually kept within arm's reach of the manager; if he wanted to get an idea of the day's sales, he simply opened the ledger or, even more directly, checked the cash drawer.

This rudimentary system, however, had one major drawback: it got tired and careless under high volume conditions. And during the next 40 years volume was to become the byword of American industry.

INFORMATION EXPLOSION

From about 1900 to 1940, U.S. commerce expanded at a prodigious rate. The railroads pushed west, north, and south to open new markets. Mass production techniques doubled, tripled, and quadrupled manufacturing output. Industries

grew into giants. Interchangeable parts ensured that items purchased in one part of the country could be serviced in another. American ingenuity produced 1,330,000 new patents in the first third of the 20th century alone.

But along with change came the information explosion. The data itself wasn't that much different. There was just so much more of it. Managers were confronted with the problem of sorting through great amounts of information to find meaningful data. Often the time and cost of searching it out didn't pay off.

Of course, there was some information that had to be found. Many techniques and machines were developed during the first half of the 20th century for this purpose. But, for the most part, the kind and form of information flowing to top management wasn't commensurate with the decisions they had to make.

With the advent of the electronic digital computer, management had a tool capable of drastically increasing information flow. Characteristically, the early data processing systems were concerned with replacing previously manual systems rather than with presenting specific data to management. This was to be expected. The tool was new, and industry first had to understand its nature before actually taking advantage of it.

But it didn't take long for management to realize that their new tool was the depository of a huge amount of company information. To process payroll, for example, meant recording all personnel, salary, and labor data in punched card or magnetic tape form. The accounts receivable file, by the same token, contained a wide variety of customer, sales, and credit information. And computerized inventory records held much more than just the current stock status of a given item.

Management soon discovered that programming made it possible to retrieve all or part of a given record either periodically or on demand. Moreover, by applying certain mathematical parameters to the file, they could pick out only those items or accounts falling under or over a predetermined safety margin.

Thus, the next step was development of systems for exception reporting on a routine basis. These systems were, in effect, the forerunner of present-day computerized management information systems. Instead of overloading management with reams of routine data—a printout of the entire accounts receivable list, for instance—the computer was programed to pick out only those items that called for management attention. In this way, top executives were able to get information they wouldn't or couldn't get otherwise because of the time, effort, and money involved in searching it out. And they were able to get it in time to take decisive action.

TWO-DIMENSIONAL DATA

Unfortunately, these early management information systems were on a segmented or vertical basis; i.e., they were restricted to one particular area or

aspect of the company's operations. The inventory system, for instance, concerned only the flow of goods and took no cognizance of current sales, financial conditions, or long-range planning. The payroll exception reporting system did a good job of calling management's attention to labor oddities, but ignored the effects of manufacturing output on present sales conditions. Thus, management was provided with only two dimensions of what is really a three-dimensional picture.

Traditionally, a top-level manager makes his decisions as a result of many inputs. These inputs include both internal and external data. Internal information, of course, is concerned with virtually everything that happens within the company. External information comes from such sources as government economic reports, independent market studies of product movement, weather reports affecting seasonal products, salesmen's reports on competition, even newspaper and magazine assessments of world, national, and local conditions.

In its broadest sense, a "total" system is one in which all information—external and internal—is channeled into a single centralized source. This source doesn't have to be a computer, but where volume is high nothing else will do. Furthermore, no other form of system can process data with comparable speed and thoroughness.

COORDINATION vs. SEGMENTATION

The computerized total management information system is, admittedly, a complicated concept. It means capturing raw data as close to its source as possible, feeding this data directly or almost directly into the computer, and then allowing the computer to apply the information to several files at the same time. After that, it means presenting the information to managers in a coordinated rather than segmented fashion. Thus, where management formerly got information directly, the computer now serves as an intermediary.

A total system is only a concept. Integration, on the other hand, is the means of implementing this concept. It involves taking a wide variety of information—internal and external, formal and informal—and through programing and the computer's mass storage abilities blending it into a meaningful whole. Thus the executive gets an over-all corporate picture.

Perhaps the most common example of an integrated system is that of an automatic inventory reorder. In a typical vertical system, the processing of a customer's order would include only preparation of an invoice and updating his accounts receivable file. In an integrated system, however, the item and quantity information on the order would also be used to update inventory records. As the computer examined each order it would note the quantity of the item requested, go to the proper stock record to see if the order can be satisfied, and automatically subtract the figure from the present total.

The computer would also be programed to make certain logical decisions. If the present order caused the stock amount to fall below a predetermined standard, for example, the computer would print out a purchase order or a factory job order. In more sophisticated applications, it might even determine the various assemblies, sub-assemblies, and raw materials involved, examine their respective inventory levels, and generate purchase or factory orders wherever necessary. And, going even a step further, it could take into consideration the manufacturing and shipping lead times of each part and generate orders so that each element in the final product arrives at the specific time needed.

If all this sounds a bit too far fetched, bear one thing in mind: integrated data processing systems of even greater scope are in existence right now. What's more, they are doing an extremely successful job of concentrating company information in a single source, using this input for a variety of necessary accounting and administrative jobs, and providing meaningful output to managers in a concise, timely, and accurate manner.

Now let's turn to the third of the three important trends in management information today, the dynamic system. Here we tread on the thin ice of controversy.

Despite a certain amount of skepticism, we are once again met by the fact that dynamic systems are already here and that there is considerable evidence that their use will grow. For this reason alone they are worth close appraisal.

The "dynamic system" is characterized by three essential aspects. First, key data is input on an immediate or real-time basis, usually at the point of origin. This could mean, for instance, using a punched paper tape created by a cash register as direct input to a computer, or setting up some sort of card or optical reading device at the point of sale which feeds information directly to a computer. In any case, the objective is to capture vital information as early as possible so that it can be processed and presented to the proper management for immediate use.

Second, the dynamic system often involves a simulation exercise. That is, some aspect of the business—or the entire business—is mathematically modeled within the computer so that management can present hypothetical "what if" questions to it and receive a reasonable answer. With key variables being fed to this model on an almost immediate basis, management can determine in minutes, rather than in days, the profitability of several different courses of action and arrive at the most effective combination.

Finally, the dynamic system is designed to minimize the time, cost, and effort of system changes. Today, for example, a change in computer hardware or a major system change too often necessitates re-programing and re-education of the users. With the dynamic system, these changes can be made without upsetting existing procedures or reassembling existing data banks.

It is worthwhile at this juncture, however, to put these total, integrated, dynamic systems in perspective. Because there is almost no limit as to what can

be processed and presented to management on an on-line basis, it is tempting to misuse these systems. Management doesn't need *all* information on an immediate basis. For example, fixed costs won't change minute by minute. Using hardware to present this information on a real-time basis is a waste of time and money. Rather, these systems must be used to identify and control only key data—data on those aspects of the business which demand immediate top-level action.

CONTROL LIMITS

A second danger lies in management over-reacting to data furnished by the system. I doubt we'll ever reach the point where systems will explain the reasons for *every* minor fluctuation in sales. Therefore, instead of over-reacting to random, minor fluctuations, management should establish control limits to identify those fluctuations which deserve attention.

A major insurance company in New York processes about 15,000 new insurance applications at any given time. Each application must go through a variety of departments, including medical, underwriting, policy service, and so forth. Finding one application out of the many used to present quite a problem.

Today the company is using a total, integrated, dynamic management information system to keep track of each application. As an application hits various processing points, on-line input/output devices are used to feed control information directly into a computer. The computer applies this information to application records stored on its direct access disks. When a manager wants to know where the application is located and what has been done to it, he simply picks up a phone on the terminal, uses the touch-tone buttons to key in the application's number, and the "voice" of the computer provides the answer.

Another example of "voice-answer-back"—wherein the computer actually formulates a verbal response to a management query—is the New York Stock Exchange. In this case member brokers need only dial a computer to get the up-to-the-minute activity of any stock on the exchange. And while this response may be only a matter of seconds or minutes faster than the ticker tape, it accomplishes a vital management job by providing information when and how it is needed.

Still another example of the dynamic management information system is found in the office of the president of one of the nation's largest manufacturing firms. The executive has a visual display unit in his office on which he can call up a wide variety of company information. He can, for instance, get the weekly sales figure, the month-to-date figure, the year-to-date figure, and a comparison of all of these with figures for previous years. He can also ask for production data, check to find out the current status of accounts receivable and accounts payable, and get a precise listing of all pending orders. While this information is presented to him as a series of totals, he can break them down simply by

pointing to the figure with a light pen. He gets information when and where he wants it, he gets it in confidence, and he gets it without cluttering up his desk with a lot of extraneous paperwork.

The "decision room," where top executives can get visual display of key data on demand, examine alternatives and see the result, is a reality today in a number of corporate situations. Available and practical at present only to the largest and most progressive companies, such facilities portend the future in one form or another for all corporate enterprise.

Many legitimate questions are still to be resolved about management information systems. These questions, however, should not obscure the fact that integrated information systems are already here and are being used effectively by many firms. Neither should they lessen the sense of urgency felt by those close to systems design for the development of more effective systems.

There is a wide range of opinion concerning when companies should develop and implement these systems. There are some who suggest a "let's wait and see" attitude. After all, they reason, it took 20 years for EDP to reach its present point, and another 20 years won't make that much difference.

At the other end of the pole, there are those who won't or can't wait another day. In a sense, they over-react to urgency by installing the hardware first and worrying about system design later.

In my opinion, the "middle of the road" is the best approach. On the one hand, things are happening and, unless positive steps are taken now, the lengthening lead time for effective system development will make it difficult for a company to catch up with its competitors. On the other hand, a headlong plunge may do more harm than good.

PRECISE, PROFESSIONAL PLANNING . . .

What is needed is precise, professional long-range planning, planning that will show the company where to go, how to get there, and how to employ its resources toward that end.

The starting point of such thinking should be at the very top of the company. A management information system isn't simply a beefed-up accounting report. It is, quite simply, a flow of data designed to answer specific management needs. And the only way these needs can be ascertained and planned for is by having systems objectives originate at the highest level.

It must be stressed that management isn't always in a position to ascertain these needs. This is the old problem of not being able to see the forest for the trees. For this reason the first step in management system design might very well be the securing of professional personnel either by hiring capable system analysts or securing outside consultant services.

From this point management should proceed to a series of pertinent questions: How are we doing in comparison to our competitors? How is the company

holding up in the current economic environment? Are we meeting the goals set last year, five years ago, and ten years ago?

While these questions might seem elementary, the answers may very clearly reveal gaps in existing management information and even point the way toward organization of data so that it better serves the decision-making needs of management.

If, for example, a company begins to lose its competitive position, more questions are in order: Are we suffering talent gaps along the way? Is top management getting a clear sales picture—and getting it fast enough? Is there a breakdown in quality control and, if so, where is it? Are we being responsive enough to customer needs? Is a firmer hand needed, and where?

These questions, in themselves, indicate a breakdown of communication between top executives and operation management. And answering them on a once-in-a-while basis isn't the solution. If there is real concern about the inroads of competition, this information should be available on a routine or on-demand basis.

What about the effects of the current economic environment? Here, too, an answer might reveal the major problem. If the company is suffering from the effects of dynamic economic changes, the reason may be a basic inability to anticipate these changes. In this instance the problem isn't one of fast action and fast decision but of effectively using current information to anticipate future conditions.

What I am talking about here is the use of simulation to prepare alternative courses of action in order to meet various forms of change. The information system takes current data and applies it to a mathematical model of the company. Thus, where management once had to depend on intuition, it can now make decisions based on scientific consideration.

. . . AT THE HIGHEST LEVEL

Setting goals, too, is aided and enhanced by rapid, selective, and scientific use of routine company information. While formulation of long-range plans usually is a function of middle management, the ultimate responsibility for achieving the goals lies with top management. Therefore, still another objective of a management information system is the presentation of data in a form and manner that provides support to this responsibility.

Planning a total management information system is a managerial and organizational rather than technical activity. It should start at the highest level of the company. Thinking should not be in terms of "what kind of information can I get from our accounts receivable report" but in terms of "what type of data do I need in order to run the company more effectively and more profitably." Once these questions are answered, management can tackle the

problems of how to organize raw data for input to an information system, and how to process this raw data for effective output. Only at this point should the questions of hardware be considered.

It has been said that nothing can delay an idea once its time has come. Given the new capabilities of the third generation computer, who has the courage to say that the time for management information systems to take a giant step toward totality has not come? It suggests at the very least that, since the rate of change affecting the techniques of management and organization will not remain constant, the question of where a given company will be 20 or even 10 years from now may be determined by what plan and course of action in systems design are taken now. Catching up may be a thing of the past.

READING 6 DISCUSSION QUESTIONS

1 What are the three essential aspects of the "dynamic system"?
2 What are some possible dangers in the use of dynamic systems?
3 What guidelines for information-system design are presented in this reading?

READING 7 COMPUTER TIME SHARING*

BRANDT R. ALLEN

Computer time-sharing, once an exclusive service for scientists and engineers, is fast becoming important to the business manager. This is a service that one ordinarily buys on an incremental basis from a service bureau (vendor). These vendors offer a variety of services and it is important that the manager contemplating use of time-sharing understand them in order to select the vendor or vendors most appropriate to his needs. Some of the more important variables are introduced in this paper.

COMMUNICATING WITH THE COMPUTER

From management's point of view the use of time-sharing is similar in many ways to that of a TWX system. The firm leases an inexpensive terminal (such as a teletype) and a communications line (with time-sharing the communications line is actually an ordinary telephone line—nothing more, nothing less). Just as the

*Reprinted from *Management Accounting,* pp. 36-38, January, 1969. Reprinted by permission from the National Association of Accountants, 505 Park Avenue, New York. Dr. Allen is an assistant professor of business administration, Harvard University.

TWX system allows you to send and receive messages from other TWX terminals, the time-sharing system allows you to send and receive messages from a computer, in this case a special time-sharing computer. This computer is ordinarily owned and operated by a vendor such as GE or IBM, but the computer may actually be hundreds of miles away. You are billed on the basis of the amount of time you actually spend connected to the machine (and there might be some minimum monthly charge—such as $100). Since different vendors use different types of computers and often specialize in different types of service, many businesses often use several vendors. This is possible because the communication between the computer and your terminal is through the telephone system—to use another computer *you merely dial another number.* The terminal is thus a general purpose input device to a variety of services provided by these vendors.

Until recently communicating with a computer has been very difficult—anyone who has had to deal with computer programmers, systems analysts and computer operators knows the difficulty of getting even a simple problem solved on the machine. Time-sharing has been designed to significantly minimize this communication problem. In fact, it is the result of an attempt to provide computing power to the man who has a problem (rather than a programmer)—even if he has never worked with a computer before.

Let's look at an example—suppose we take a simple discounting problem: What is it now worth to be able to receive $1,000 in five years at an interest rate of 7%? We certainly do not need a computer to solve that but we will try it anyway as an example. We remember that the present worth (W) of any amount (A) in the future is

$$W = A/(1 + K)^{N}$$

where K is the interest rate and N is the number of years in the future. For our problem

$$W = \$1{,}000/(1 + .07)^{5}$$

To solve this on the computer we go through the following steps:

1 Switch on the terminal (teletype) and dial the computer's telephone number.
2 When the connection is made, the computer will ordinarily type hello and ask who we are (for billing purposes).
3 We type our account number and are now ready to enter our problem.

All we must now type is:

```
TYPE   1000/(1 +.07)△5
```

and the computer will type out the answer:

```
1000/(1 + .07)△5 = 712.99
```

The little triangle is the computer's way of signifying exponentiation. Another way to do this would be the following:

```
SET   N = 5
SET   K = .07
SET   A = 1000
TYPE A/(1 + K)△N
```

again the machine would respond with

```
1000/(1 + .07)△5 = 712.99
```

If we carry this example one step further we can produce a "program" which will work for all problems of this type. We will give each line a number and add another step:

```
1.1  DEMAND A,K,N
1.2  TYPE A/(1 + K) △N
```

Then all we need to do to "run" this program is type "RUN." The "demand" step allows us to type in any amount (A), interest rate (K) and number of years (N). Here is an example: (what you type is underlined)

```
RUN
A = 1500
K = .09
N = 20
     1500/(1 + .09)△20 = 267.65
```

The words like DEMAND, TYPE and SET are commands that one must learn like a foreign language. There are only a dozen or so and can easily be mastered in a few hours. Indeed many of the current users of time-sharing knew nothing about computers or programming prior to their use of the system.

Furthermore, most time-sharing vendors have hundreds of standard programs already written which one might use. This is perhaps the easiest way for a company to start using time-sharing. Most businesses subscribe to several vendors. One reason for switching from vendor to vendor is to use different programs in their library. Suppose you have a sales forecasting problem and Vendor X has a multiple-regression program in its library—just call Vendor X and use the program. If later on you wish to use a program from Vendor Y—just call.

WHY IS TIME-SHARING USEFUL?

Perhaps we should now look at why time-sharing seems to be useful for business problems. Some of the reasons for its rapid growth are indicated below.

CONVENIENCE A remote terminal can literally be installed wherever there is electric power and telephone circuits. Many business subscribers have terminals in their offices—some in their homes. There are a number of portable terminals on the market which can be operated from any standard telephone without special installation.

PROGRAMS WRITTEN QUICKLY On a conventional (batch) computer, program development is often a matter of weeks or months. Time-sharing can cut drastically into this delay—many users report problems solved in a fifth or a tenth the time it would have required on a batch machine.

PROGRAMS RUN QUICKLY This is perhaps the most noticeable feature of on-line computing—whenever it is necessary to run a program it can be done in minutes or even seconds. Compared to time-sharing, running a program on a batch computer is like placing each phone call you make through an operator who takes from thirty minutes to four hours to make each call. Of course, rapid response is not without its premium; it may cost considerably more than conventional processing for a particular run with the current generation of on-line systems.

EASY TO GET STARTED While it may take months or years to install a conventional computer, most businesses can acquire on-line service in a matter of weeks or even hours. And it is just as easy to divest yourself of this capability if it fails to meet your needs.

RENTAL Much of the growth of time-sharing must be ascribed to accounting convention. A manager might fight for three years to justify an in-house computer, programmers, analysts, machine operators and necessary space. Yet often he can, without question, expense two or three hundred dollars per month for on-line computer service. Remote terminals are typically rented; computer and telephone line charges are computed on a usage basis; in short, everything is expensed and nothing need go through formal capital expenditure procedures.

SIMPLE—EASY TO USE From the example presented earlier, the reader will note that many programs are almost English-like in nature. This simplicity comes at a price, however; most time-sharing systems cannot match the performance of even modest conventional machines in various categories: speed, size of program, amount of data, etc. This need not always be the case and will tend to be of lesser significance in the future.

MAN-MACHINE INTERACTION This is probably the most important feature of on-line computing systems: the problem solver (not an analyst, programmer or machine operator), communicates directly with the machine. Hence, the decision maker is not plagued with various intermediaries—he works directly with his problem and the machine. This man-machine interaction frequently leads to ideas, insights and an understanding of the relevant problem variables and their interrelationships that have not been possible using conventional methods— either with or without a computer.

HOW IS TIME-SHARING USED NOW

Some of the current business applications of time-sharing are listed below:

Production Scheduling
Inventory Control
Budgeting
Sales Forecasting
Cost Analysis
Pricing Strategy
Business Simulation
Market Evaluation
Facilities Planning
Lead-time Projections
Merger Analysis
Personnel Scheduling
Cash-flow Forecasting
Product Costing

Time-sharing is used in many small firms which have never been able to justify even the smallest in-house computer. At the other extreme there are very large companies, where the use of time-sharing is growing rapidly.

WHAT WILL BE AVAILABLE IN THE FUTURE

Looking ahead (three years is "long range" in this industry), there is a great deal of effort to considerably expand the services provided by the time-sharing vendor. There will be more vendors—many on a national basis. At least six established vendors have announced plans for or are already "national distributors."[1]

A number of others are known to be moving in this direction. Although there will undoubtably be some fatalities along the way, all of the signs indicate a growing number of both small and large vendors.

There is a trend toward bigger and faster machines, at lower rates, and with the capability to "converse" with many more types of remote terminals. The performance gap between time-sharing computers and batch computers will tend to narrow.

With increased competition, improved computers (hardware), better operating systems (software), economics of scale and lower communication rates, the cost

[1] General Electric, IBM, University Computing Company, Com-Share, Tymshare, ITT, and White, Weld and Co.

to the user must certainly be reduced. While current charges are generally from $15-30 per hour, they may be in the $5-15 range in the next three years.

One of the current weaknesses of time-sharing, for the business user, is that he could not store and assess large amounts of information. Vendors are already beginning to provide storage for very large and in some cases unlimited collections of data.

Vendors with multiple machines will develop means to "interconnect" them so that when one fails or is overloaded, another can take over the work. The user is given service with much higher reliability. Such interlocking should allow national and multi-national firms to use the computer network to collect, process and transmit data and at reasonable cost. Not only could such a system be used to collect information such as sales reports, but management control and information reports could be prepared and, when ready, the recipients' terminal could be dialed and the report printed. Of course, this capability is available now, with human operators and one of the wire services.

As the number of vendors increases and competition becomes more intense, some will begin to specialize in certain types of service (this is already taking place today, although on a small scale). This specialization will be along a number of lines. Some will concentrate on collecting and maintaining special data, such as basic economic data, marketing analyses or financial data. Others will develop special programming languages for a particular group of users such as accountants, financial analysts or civil engineers. In appealing to special user groups, the vendors may provide collections of programs of particular interest to that group. We might find all three: special data files, special languages and special library programs.

WHAT TO LOOK FOR NOW

Although there are hundreds of variables to consider in selecting a vendor, at least the following require particularly close attention:

Cost vs. Performance
Vendor's Library and Service
Availability and Reliability

COST—PERFORMANCE Briefly stated the question is simply, what do you get and how much does it cost? With respect to cost you will find that not only are the rates different for various vendors, but the method of computation may be different. Generally vendors bill on any or all of three items:

1 *Connect time.* The total elapsed time from the time you dial into the computer till you disconnect.
2 *CPU time.* The total amount (usually measured in seconds) of actual computer time: i.e., you may be connected to the machine for an hour while

working on a problem, but you might only use 30 seconds of actual computer time (CPU = Central Processing Unit).

3 *Storage charges.* Programs and data files can be stored "on-line" for ready access. This storage is typically billed on an average-volume-used basis.

In addition there may be minimum monthly charges, special billing packages (such as unlimited usage of one "line" or terminal with so much storage for, say, $500/month), and other combinations of the above three measures. For example, one vendor might have the following rate schedule:

1 No charge for CPU.
2 $12/connect hour, 8:00 a.m.–6:00 p.m. weekdays, $8/hr. other times.
3 No charge for X units of storage per dollar of connect time. $3/month for all units of storage above that.

In comparing various vendor rate systems, one must always be reminded that the basic computer speeds themselves may be quite different. Consequently you may find a vendor with a relatively low rate who also has a relatively slow speed machine. With respect to performance, the basic question is: What can the system do? What programming languages are available? Is there a simple language such as BASIC, CAL, or JOSS; and, is there a more powerful one for experienced programmers? It is necessary to have both—the easy one for beginners and those who are not professional programmers, and the more powerful one for jobs that require better performance. The easy languages sacrifice some performance (such as speed) for convenience, the more powerful are more difficult to use.

Important performance factors other than speed and ease of use are:

1 *File storage.* How much storage is available, how convenient is it to use, are there special file maintenance languages such as a text editor?
2 *Flexibility.* Can multiple users in remote locations easily provide data to central files? Can reports be directed to various users (can the computer call up a user at a certain number, turn on his terminal and leave him a report), and can multiple users interact simultaneously using separate terminals? Does the system "grow" with the user? Does the system allow you to use different types of input/output terminals—or must you use one supplied by the vendor and thus be unable to use another vendor's systems?
3 *Variable Speed Response.* Can you direct the system to respond quickly (at high cost) or slowly (at moderate cost) or at its convenience (at low cost)? The requirements for a speedy response are not always the same. Although this is not a feature on many of the current systems, it is very important and will become more so in the future.

VENDOR'S LIBRARY How many programs are there in your problem area—how good are they (do they have errors, do they do the job the way you

want it done, are they efficient, easy to use, flexible)? Is there any way in which they can be modified?

SERVICE What can the sales and support people of the service bureau really do for you? Does the vendor have good, well written, easy to use manuals for all programming languages, subsystems, operating system and libraries? What can and will the support people actually do for you—write programs, make changes in the system?

AVAILABILITY Is service available 24 hours a day, seven days a week, or is the service bureau only "open" on weekdays and for limited periods of time? Even if the machine is running—will you always be able to "get on" or does the vendor run his operation such that the entire machine is busy during most of the day? Time-sharing machines have a capacity in terms of the total number of simultaneous users. If a vendor is heavily loaded, you may have difficulty getting on the machine. Even if you get on, a heavily loaded machine will not perform as well as a lightly loaded one; you thus pay more for less service.

RELIABILITY This has always been a major problem with commercial time-sharing vendors. Reliability problems may inconvenience you in any of three ways: the system may be inoperable when you wish to use it; the machine may malfunction with or without notification while you are using it; and malfunction may lead to the loss or damage of programs and data files saved in your library. Most vendors have improved reliability to the point where malfunction occurs only several times a year and lost programs of files can generally be restored. However, it is still a major variable to be considered when comparing vendors.

At a different level is reliability of the service bureau as a business. There are a great many small, undercapitalized vendors who are struggling to stay in business. You ought to ask yourself: will he be in business next year? Unfortunately, not all of the current service bureaus will survive the next eighteen months.

SUMMARY

Time-sharing is here to stay. For the first time, the business manager, or his staff assistant, is able to use a computer directly and many businesses are finding it attractive to their needs. Some managers are using time-sharing with good results. It promises much more in the future. Its disadvantages, real or imagined, are of lesser importance, primarily because of the cost of experimentation. However, it will be found that trial and termination, if necessary, can be small—both in time and expense.

READING 7 DISCUSSION QUESTIONS

1 Why is timesharing experiencing such rapid growth—i.e., why is it useful?
2 Identify and discuss some ways in which timesharing is now being used.
3 Discuss the anticipated future developments in the services offered by timesharing vendors.
4 What factors should be considered by a small business in selecting a timesharing vendor?

READING 8 TIME SHARING IN THE NEAR FUTURE*

RICHARD T. BUESCHEL

"Three years ago, no more than 500 terminals were on-line to time-sharing computers. Today, General Electric alone serves more than 50,000 time-sharing customers, and the field is one of the most rapidly growing businesses in the world."[1] Time-sharing is passing from potential to actuality at an increasing rate.

No matter how we view it, 1968 will stand as the "break-through" year for the time-sharing industry. The services are burgeoning (see Exhibit 1 and Table 1). Connected terminals are skyrocketing (see Exhibit 2). And in the present year the developmental emphasis is rapidly shifting from the academic to the practical world. Certain trends are now apparent in the industry. We will follow those trends into the future and try to discern the coming impact of time-sharing.

BUSINESS APPLICATIONS

We can best begin to extrapolate the future evolution of commercial time-sharing by isolating its present impact on industry.

Today the typical user is no longer buying just raw computer power alone. He is beginning to buy both applications and computing power. And the applications are increasingly being found in the business area. Time-sharing is being recognized as a powerful aid to business decisions. The once-remote computer has been replaced by the familiar teletypewriter or electric typewriter at the manager's point of contact. Conversational languages are becoming less obscure under the push for expanding time-sharing resources. Strong founda-

*Reprinted with permission from *Computers and Automation,* January, 1969, copyright 1969 by and published by Berkeley Enterprises, Inc., 815 Washington St., Newtonville, Mass. Richard Bueschel is president of Time Share Corporation, Hanover, New Hampshire.

[1] J. Stanford Smith quoted in "Share and Share Alike" by Bohdan O. Szuprowicz and T. Richard Elliott, Jr., *Barron's,* September 23, 1968, p. 3.

EXHIBIT 1

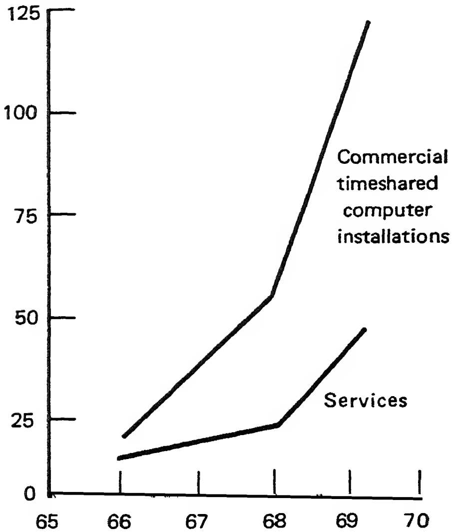
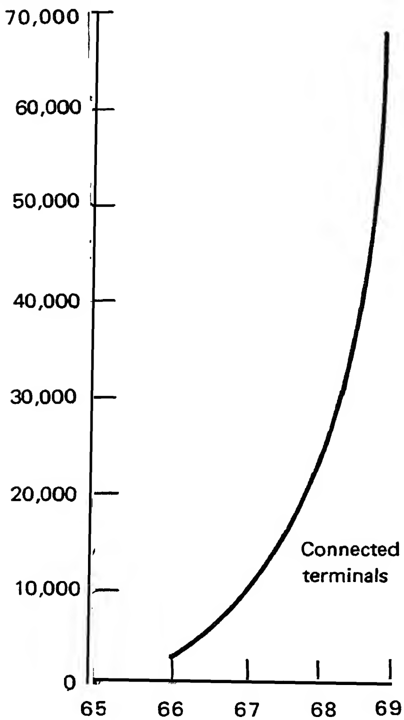


EXHIBIT 2



tions in time-sharing are now an integral part of management education being provided by the nation's top graduate business schools. Numerous time-sharing articles have appeared in the leading business periodicals. The concept is enjoying growing exposure in the commercial world. And this trend is being accentuated as large commercial data files are becoming available on a more economical basis.

The application of time-sharing was initially oriented toward engineering and scientific problem solution but is now shifting toward business uses such as financial analysis. This direction is exemplified by White, Weld's subsidiary, Interactive Data Services, which operates a system based on its First Financial Language (FFL). The Boston Company and Dial Data have jointly undertaken a similar venture. Goodbody's financial analysis is offered through ITT's Reactive Terminal Service (RTS). First National City Bank and other large financial institutions are moving quickly in this area.

MANAGEMENT

Although time-sharing in business is most heavily used in financial applications, its suitability to other business areas is increasingly apparent. Management consultants are now pioneering its use in a wide variety of simulation studies, but also top corporate management in such firms as Pillsbury and McKesson & Robbins have recognized the advantages of accessible computer power as a management aid. Time-sharing is appearing in such diverse enterprises as advertising agencies (media models) and wholesale houses (real-time inventory models).

HOSPITAL ADMINISTRATION

Another fertile field for time-sharing appears to be hospital administration. With skyrocketing costs and their comparative lack of administrative talent, the hospitals badly need the additional capabilities that time-sharing can bring. A pioneering effort is now underway at the Monmouth Medical Center under Mr. James Fahey. This first completely integrated Hospital Management Information System should help set the standard for future hospital administration. Other efforts such as Medinet are also attempting to pioneer in this area.

The most important development in time-sharing, however, is not as visible as the various application packages being used today. Following the Dartmouth Tuck School example, Harvard and other leading graduate business schools are making time-sharing an integral part of their curricula. The new M.B.A.'s are bringing a special expertise into business. They will be a catalyst in the development of new management patterns. They will be the facilitators and initiators of the increasing importance of time-sharing.

The impact of time-sharing on commercial enterprise is beginning to be

significant today. "To thousands of sophisticated businessmen, the time-sharing terminal is a helpful partner who makes life a lot more productive."[2] Tomorrow's impact will be profound!

EDUCATIONAL IMPACT

While we expect time-sharing's impact on commerce to be profound, its significance for educational practices will be even more dramatic. It will change the face of education in America.

The present effort in computer-assisted instruction (CAI) is well known, but the more generalized "education utility" will carry more significance in the future. The learn-by-rote, canned-learning approach of CAI does not really constitute a pedagogical innovation. It simply is old practice automated. The new interactive programming languages, however, will open up entirely new learning resources in the coming age of information explosion.

For the first time man faces the certainty of skill obsolescence. The technician's present skills will not match tomorrow's needs. And the once-comfortable businessman can no longer afford the luxury of operation by "experience". To succeed will increasingly become synonymous with keeping abreast. And the act of keeping abreast will call new educational forms into existence. Time-shared computer systems are now evolving which will permit continuing professional education to become a reality. It is possible that the generalized time-shared system can be tailored for educational uses.

A "SKILL UPDATING DEVICE"

To appreciate the value of a time-shared education utility as a skill updating device, let's look ahead and try to discern the outline of such a system. Because engineers are particularly susceptible to skill obsolescence, we'll consider the "engineering education utility". There will be no single utility computer center. Rather, a series of interconnected regional facilities will be scattered across the nation. Input into each facility will be a shared effort of both the engineering schools and firms. Likewise, the output of the system will be equally available to both academic and practical users. Because the facility will be primarily used as an updating resource, the focus of the input will be on the most current and developing engineering applications. The universities will retain their traditional role of providing the base of the profession, but the utility will be dedicated to updating it.

Specific input into the utility might be in the form of professional articles to be microfilmed for graphic display, new computational routines and applications, and verbal descriptions of new engineering techniques. Also implicit in

[2] *Ibid.*

TABLE 1 FIRMS OFFERING TIME-SHARING SERVICES

Allen-Babcock Computing Los Angeles, Cal.	IBM Quicktran New York, N. Y.
Applied Logic Corp. Princeton, N. J.	ITT Data Services Paramus, N. J.
Automatic Data Processing, Inc. Clifton, N. J.	Information Network Corp. Phoenix, Ariz.
Bolt, Beranek & Newman Cambridge, Mass.	Interactive Computing Corp. Los Angeles, Cal.
Call-A-Computer Raleigh, N. C.	Interactive Data Services New York, N. Y.
C-E-I-R, Inc. Bethesda, Md.	Keydata and Adams Associates Cambridge, Mass.
Computel Systems, Ltd. Ottawa, Canada	Management Information Columbus, Ohio
Computer Network Corp. Washington, D. C.	Marquadt Corp. Phoenix, Ariz.
Computer Sciences Corp. El Segundo, Cal.	McDonnell Automation St. Louis, Mo.
Computer Sharing, Inc. Bala-Cynwyd, Pa.	Multi-Access Computing, Inc. Waltham, Mass.
Computer Time Sharing Minneapolis, Minn.	On-Line Systems, Inc. Pittsburgh, Pa.
Computrol Systems, Inc. Atlanta, Ga.	Philco-Ford Corp. Willow Grove, Pa.
Com-Share, Inc. Ann Arbor, Mich.	Rapidata New York, N. Y.
Control Data Corp. Minneapolis, Minn.	Remote Computing Corp. Los Angeles, Cal.
Data Network Corp. New York, N. Y.	System Development Corp. Santa Monica, Cal.
Dial-Data, Inc. Newton, Mass.	Technical Advisors, Inc. Wayne, Mich.
Direct Access Computer Corp. Detroit, Mich.	Tel-A-Data No. Miami Beach, Fla.
Eli Time Sharing, Inc. E. Paterson, N. J.	Time Share Corp. Hanover, N. H.
GE Information Systems Bethesda, Md.	Time Sharing Systems, Inc. Milwaukee, Wis.
Graphic Controls Corp. Buffalo, N. Y.	Tymshare, Inc. Palo Alto, Cal.
Greyhound Computing New York, N. Y.	U. S. Time-Sharing, Inc. Washington, D. C.
IBM Call/360 Basic New York, N. Y.	United Computing Systems Kansas City, Mo.
IBM Call/360 Datatext New York, N. Y.	University Computing Dallas, Tex.
IBM Datatext New York, N. Y.	VIP Systems Washington, D. C.

the notion of a dedicated engineering education utility will be the continued development of engineering programming languages. The utility computer will index various inputs and store them by the various classifications of the engineering profession. The system user will be provided with an index guide at the outset which will enable him to retrieve the most current developments in his own field, or to scan the most recent developments in others.

The education utility will provide a powerful tool to hedge against the pressures of the information explosion. It will also establish a long-life pedagogical relationship between the individual and the education system. In a very real sense it will establish a man-machine symbiosis.

HARDWARE DEVELOPMENTS

This view of the evolving future would be speculation without an appreciation of the current developments in the hardware sector. Two major trends are discernible. In the first place, super systems (e.g., CDC 6600, S360/85, B8500) are well along in development. These large systems allow us to predict the coming of education utilities, intra-industry information banks, and large-scale general purpose utilities.

A second characteristic of the industry lies in the development of many new, small, general-purpose, time-sharing systems (e.g., DEC TSS-8, HP 2000A, the soon-to-be-announced Varian time-sharing system, etc.). We should expect these smaller systems to form the basis for internal management information systems, inventory control systems, and self-sufficient institutional systems for use within industries and institutions.

While, at first glance the two hardware tendencies appear divergent, this apparent divergence may be illusory. The new DEC TSS-8 will have a direct interface to the DEC PDP-10 permitting the smaller time-shared system to call upon the capabilities of the large system when required. In this same direction, the Advanced Research Projects Agency of the Pentagon, long the angel of time-sharing, is now embarked on a project to connect together various university time-sharing centers. The resulting system is to be based on a series of yet-to-be-designed special-purpose communication computers. A.R.P.A. plans to closely monitor the effectiveness and properties of such a network.

THE "FIRMWARE" CONCEPT

Complementing the hardware development is a significant new development — the "firmware" concept. This concept consists in building a function or an entire compiler into hardware. This is not really a new concept: Allen-Babcock Computing used it to implement PL-1 on its 360/50; and IBM uses ROS (Read-Only Store) in the 360/25 and /85. What is new, however, is the broad use of ROM's (Read-Only Memory) now being made and planned for new

time-shared systems such as Standard Computer's IC 7000. Here entire compilers and executive routines will be built into the memory hardware. The use of ROM's or ROS's should improve compile and execution times considerably in a time-sharing environment. Other systems recently introducing ROM's include Interdata and Datacraft.

Perhaps the most significant developments taking place in time-sharing today are the growing ability to handle large volumes of data. This capability unlocks the commercial potential of time-sharing. The evolution of large file-handling systems is well along; it is itself spawning new file-handling languages as well as file systems. Most of the people developing large file-handling techniques are not talking; this has become one of the big areas of trade secrets. Much of the pioneering work is being done by commercial firms, such as Applied Logic's 1.15 billion character file system based on the Bryant drum and disks. The reason that the commercial vendors are leading the way is the potential payoff in rental storage for the large commercial time-sharing system. The universities also are still working heavily in these areas. This is also an area of prime focus for the Univ. of Calif. at Berkeley, Dartmouth, and others at this time.

Supplementing the developing file-management systems is an indication that mass storage costs will begin to drop rapidly in the next 15 months. Disk prices are coming down. New techniques of mass storage are being explored. Foto-Mem, a new firm in magnetic-film-optic storage, is projecting a new storage system, now in prototype, to store over 100 billion characters at a price well under $1.00 per million characters. Large low-cost files, and appropriate file management systems, coupled with the increasing capabilities of firmware will significantly change time-sharing in the next two years.

CONCLUSION

This has been a conservative look into the future. Time-sharing will change the way man learns and works. It will open up the possibility of continuous learning, and it will make possible a far broader range of managerial control. If the potentials in these opportunities are actualized, time-sharing will have a profound impact on our way of living in the coming decade.

READING 8 DISCUSSION QUESTIONS

1 Identify and discuss the trends which promise to reshape the timesharing industry.

2 "Time sharing will change the face of education in America." Discuss this statement.

3 Summarize the developments in hardware and software described in this reading.

READING 9 BREAKTHROUGH IN MANAGEMENT INFORMATION SYSTEMS*

PAUL KIRCHER

A major problem of management information systems has been the development of ways to reach stored information inexpensively and on demand. Packaged programs recently announced by software companies, and others, should enable managers to obtain information from their computer data files much more efficiently. This new approach promises a real breakthrough in designs of information systems.

Computer files now contain a wide range of information. Much of the data is used only as a part of regular processing runs and does not appear on reports. Occasionally the data could be most useful to managers and others, but it cannot be retrieved by the existing programs. In the typical case, for example, the program used to process payroll will not retrieve special purpose information such as names of employees with special skills. Previously, special programs were required to do this. Now multipurpose programs are becoming available in a form which will make their use quick and economical for this and for unrelated tasks.

The problem of file maintenance has also been widely recognized as an important aspect of computer systems. A number of software companies and the government have been working on the development of new program packages to create and update files. Programs to do this task are in some cases being combined with the programs which permit extraction of data on a demand basis. Together these programs offer managers a powerful new tool.

This article investigates the reasons why these developments have occurred. It indicates how the new programs can be used by managers, systems designers, and accountants to create and maintain files, and to retrieve special purpose information.

Creation of a computer program to process a major section of an enterprise's information system is a difficult and expensive task. There have been a number of attempts to devise programs which would serve many installations and thus share the cost. To date the results have not been too satisfactory. Each company has so many distinctive features in its accounting and other systems that a custom tailored program usually is required.

For the past several years a great deal of research has been directed toward improvements in defining a proposed system and in coding it for a particular

*Reprinted from the *Journal of Data Management,* pp. 28-31, February, 1969. Reprinted by permission from the Data Processing Management Association, Park Ridge, Illinois. Paul Kircher is professor of accounting at the UCLA Graduate School of Business Administration.

computer. Attention has been devoted to methods of system analysis, flowcharting and coding.

In particular, there has been a substantial effort to create languages that are easier to learn than the assembly language for a specific computer. FORTRAN, COBOL, PL/I, and other languages have been developed. These have helped overcome the need to relearn the symbols and rules each time a system has to be programmed for a new computer.

Programs written with these aids are now in wide use. Encouraged by the success, or at least the relative improvements which have been obtained, experts have moved forward with the development of meta (higher level) languages. These further improve the programmer's ability to work rapidly and effectively.

Although it seems clear that this trend will continue, it also has been evident that these tools were not doing the whole job. Programs are being created which are more and more efficient for the basic jobs for which they are written. But they are not meeting the needs of managers for information on demand, especially when the information need may be one-time or unscheduled demand.

For example, the program that processes payrolls is rarely of any help to a manager who wants to know how many people took sick leave between January 14 and February 9, or how many managers now earning between $1000 and $1500 a month got a raise of over $100 a month last year. Yet this is exactly the type of information which managers need for specific decisions. Frequently they do not know what information they want until after they discover they have to make a decision. Then they want the data immediately.

The proposed solution is to have programs which pull out information from already existing files on request. There are several reasons why this is not always easy to do. The data may not be entered in the file on a current basis (file maintenance), or it may be difficult to retrieve data for a special request because of an interface between the program and the file, or the program simply may not be able to do the job, since it was not expected to do so.

FILE MANAGEMENT

A special program to update files must work on formats created by other programs. Record lengths and data locations usually vary from file to file for reasons which may be significant for a particular purpose. However, the variations prevent use of a fixed program not specifically written for the particular file.

One solution, of course, is to write another program. In effect, this becomes an extension of the original program. If the use is likely to be repeated often this is usually done, but ordinarily it is not worthwhile unless the usage is seen as likely to be frequent. When the demand is not foreseen and the need becomes urgent, there is a delay while the new program is written. Usually the delay prevents use of the program for the specific need which inspired it.

The only way to prevent this delay is to have a program ready for use on demand. Since it is not possible to anticipate all types of requests, it is necessary to have a program that can be adapted to each particular data need.

1 The interface between the existing file and the special program must be bridged, so the special program can work on the existing file.
2 The data requested must be definable in a way that enables the special program to find the data in the existing file.

One solution to the interface problem, used by Haskins and Sells' Auditape, is to restructure the basic file into a new file format. Then the special program can be run against the new file.

IBM has announced a General Information System for the summer of 1969. This aspect of file management is said to be a part. The company has not revealed all details of its proposed system. The method requires creation of new files and thus it means doubling the existing records, unless they are all in the new form. Since both the added file and basic file must be updated regularly, the processing and storage problems would not be trivial. "GIS" works only with "OS Systems" (128K or more of storage).

Another approach is to link the existing file to the special program by writing a new interface section of the special program. This enables it to process the original file. A new portion must be created for each different file, but it is a small part of the total special program. These programs already have been applied to situations which have different file configurations.

The new programs can also be used to create and update new files if file creation is considered desirable. However, they are designed in such a way that it is not necessary to restructure the files.

SPECIAL REQUESTS

Since special requests must be met on demand, the new programs for information retrieval are written so that the characteristics of the data to be drawn from the file can be specified by the user on a moment's notice.

To accomplish this, the special programs are designed to withdraw data from the records whenever the data correspond to the items requested. These search items may be in the form of letters or numbers. This means that the type of data requested can vary widely in significance without disturbing the procedures by which they are obtained.

In other words, the request may be for certain letters—which may be all people with a special education (e.g., "M.S.") or for the name of an inventory item (e.g., "Chicken Soup"). Similarly, it may be for certain numbers—the dollar amounts in excess of a certain given level, or for items dated later than a given date (both expressed in numbers).

All a manager needs to know is that the data he wants to find exist somewhere

in the records and the format in which he wishes to see the report. The data processing people (or his secretary) can handle the rest of the problem by supplying the "access" name for the data location, taken from a standard file description record. This means that the manager can call for data without worrying about how to get it.

The new programs will search the entire file, pull out only the items which match the requests, and show them in a form that is easy to scan. This means that the manager can cull data from a large file and obtain only those portions which are significant for a particular problem that he has at the moment in a format he can use. Thus, he can truly manage by exception.

This is not possible with most present systems. Only in those cases where the manager knew in advance exactly what he would want to ask of the system has it been possible for the programmers to include in the system methods whereby parts of the data could be obtained on demand.

The new systems enable managers to obtain information such as the following:

- Which inventory items were requested by customers but could not be delivered because of stock out?
- Which thyroidectomies performed last year received radiation treatment post-operative?
- How many engineers do we employ who can speak French?
- How much did our customers buy who live in Brentwood and ordered over $100 of merchandise last year during the Christmas season?
- Which expenses ran over 5% of the monthly average? In which month did they do this?
- How many employees earn between $800 and $950 a month?

Several approaches have been adopted to help the manager state his requests for data in the proper form. A number of these programs use a special format sheet to guide the user. An example is the Auditape developed by Haskins and Sells for use in auditing computer records. The accountant fills in data in the boxes in the form. The form is then key-punched and the data request added to the program, which then produces reports from the special file. Auditape has been licensed to the General Accounting Office, and is being tested by the Internal Revenue Service. MARK IV, a program prepared by Informatics, also uses a format sheet, but as noted, will then work on the original file.

A more flexible approach permits the user to make his request in free form. He must follow certain rules of the language—that is, he must use specific grammar and definitions—but he does not need a special format sheet. This is the approach employed by AEGIS, a general information system developed by Programmatics.

Another slightly different method is used by the Format of File Structure, or FFS, developed by the United States Government. In this case, the original file is created in a way which requires the search for data to employ a standard format.

The use of these types of programs will be made much more efficient as firms increase their communication networks with remote terminals for real time information retrieval.

HOW THE NEW METHODS OPERATE

The basic development which has enabled these new systems to be multi-purpose is, like most major breakthroughs, simple and fundamental. Rather than concentrate on the purpose for which files were created or on the significance of information, these search methods work on the fact that all information is stored in the form of letters or numbers. Therefore, if the person who inquires of a file knows the location of the information in a given record, such as the fact that it is stored in the "date" field, then all he has to do is to specify that he wishes to extract from the file all the instances when the numbers in that particular location correspond with those which he has in mind.

As another example, suppose that he wishes to take out from the file all of the customers named SMITH. If the customer name is filed in the fourth field of the record which is kept for the customers, and this field is titled "name," then he would only tell his new program that he wishes a list of all the records where SMITH occurs in the "name" field. The program scans the file, looking for a match between the letters SMITH in the request and in the file. When it finds such a match, it prints out the information about SMITH, the full record, or any specified part of the record, if that is what the inquirer desires.

It is also possible to pull information based on quantities. The number need not be equal to the number that is requested. It is also possible to request the number criteria to be less than a certain amount, or greater than a certain amount. This means, for example, that it is easy for a manager to obtain a list of all items which are outstanding that are older than a given length of time. If the date is coded in numbers, such as 10/5, it is easy to see that these items can be obtained simply by requesting all those for which the data amount is less than 10/5.

The ability to obtain information is increased by permitting certain logical combinations. For example, in some programs queries can be of the following form:

List all of the items which are less than 100 or greater than 1000 in a given field.

List all of the items which are over $100 in one field and more than a month old in another field, and all those over $1000 (regardless of date) in the first field.

List all the items which have the letters SMI as the first three letters of a five letter name.

Programs vary as to the extent to which they will provide additional processing

of the information. Auditape, for example, will prepare a statistical sample. It creates the sample to a specified degree of precision and reliability, using the numbers in the file to help calculate the sample as it reads the file. This means that a sample can be prepared and printed out for use by the auditor in one pass of the tape file.

Most programs are basically search methods to retrieve specific information. Some are modular (new sections can be inserted) so that more sophisticated mathematical treatments of the data can be added at the request of a customer.

As an example of usage, suppose an executive wishes to determine whether a loan supervisor is making loans with a high risk factor. As a test, he decides to determine the number and character of loans made where the loans exceed 10 times the monthly salary of the applicant:

```
IF (CUSTLOAN>10000 AND CUSTSALARY<1000) LIST CUSTNAME,
CUSTLOAN, CUSTSALARY
```

In this case, "CUST" is abbreviation for "customer" used to shorten the "access name."

Suppose he wishes to know delinquencies:

```
IF LASTPMT<68.02 LIST CUSTNAME, CUSTLOAN, CUSTSALARY
IF LAST PMTYR=67 OR (LASTPMTYR=68 AND LASTPMTMO<03) LIST
```

ERROR PRINT OUT NOTIFICATION

In order to make the new programs easier for unskilled operators, the programs typically report back if they encounter an incorrect command. For example, suppose the entry data is in an incorrect form, such as an incomplete request. The computer program will sense that data is missing and type out an instruction asking that a correction be prepared before proceeding further.

This practice continues at various stages throughout the processing of the program. If a condition occurs which would lead to improper results, the computer types out an instruction indicating something must be done. For example:

"Missing Open Statement"
User did not specify file to be "opened" meaning that he did not indicate the file to be queried.

"Improper File Name"
The user called for a field that did not exist in the file.

"Statement Error Beginning with Text XXXXX"
There is something incorrect in user's textual statement, such as misspelled file

name or an attempt to compare numbers with letters, or too many characters for a fixed length field.

CONTRIBUTION OF THE DATA PROCESSING MANAGER

The development of these new systems offers data processing managers an opportunity to respond to executives who want to obtain data on demand. In most cases this cannot be done inexpensively with fixed programs. Although these new programs are expensive to prepare, the fact that they can be used by many customers has greatly reduced the price to any individual user.

The programs are available for sale or on lease, but only for the use of the purchaser, since in both cases title remains with the developer. This means that the program can be resold many times, thus sharing the cost of development over many users.

It is evident that we are only in the opening stages of the development of these kinds of information file systems. The basic concepts which are being used can be extended in many ways. A company can hardly afford not to investigate these new programs. Almost certainly this approach will be expanded in the near future. Experience in using these programs will become a fundamental part of the ability expected of a data processing manager. His managers will demand that he exhibit initiative and imagination recommending the use of the new systems.

Further, since the operating executives can call for information in a simple manner, the person who actually interrogates the file may be a secretary—not a trained programmer or systems analyst. Or the executive can learn to make the inquiry himself with a remote terminal. He merely has to be able to use a reference sheet giving access names.

The ultimate possibilities of this approach will require years of experience to determine in detail. Nevertheless, it seems clear that with these new systems, the data processing manager can achieve a real breakthrough in the field of providing management with information on demand.

READING 9 DISCUSSION QUESTIONS

1 **(a)** What is file-management software?
  (b) Of what use is such software to managers?
2 How can file-processing software conserve programmer time?
3 What is the relationship between timesharing, a data base, and file-management software?
4 How might file-management programs help relieve the shortage of systems analysts and programmers?

EADING 10 MANAGEMENT INFORMATION YSTEMS: A CRITICAL APPRAISAL*

OBERT V. HEAD

he subject of "management information systems" has been much discussed, nd much maligned by both systems professionals and management people over he past few years. Both groups agree, though, that there has been a good deal of gnificant progress over the last two years or so, and it is the purpose of this aper to comment on these recent developments.

It seems appropriate to begin with a discussion of some of the basic concepts nd design objectives of management information systems. This will be followed y comments on the approaches being taken by large organizations that seem to est characterize contemporary information systems development. Finally, there vill be a brief discussion of some of the current problems in this volatile field. or although we have found solutions to many of the technical problems in ıanagement information systems, there remain others, largely non-technical, ıat threaten to inhibit the dramatic progress that might otherwise be achieved.

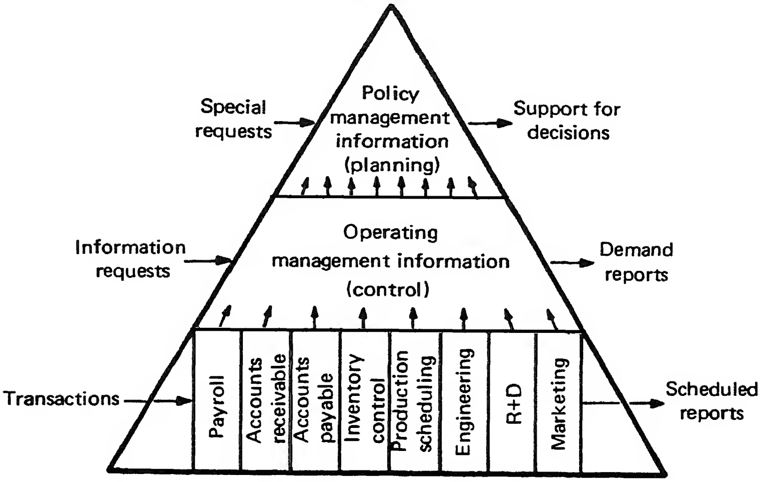
HE CONCEPT

.et us begin by describing what a "management information system" really is. o do so, it may be useful to look back over the past ten years at the ways in vhich companies have been utilizing their data processing equipment. The ottom portion of Fig. 1 indicates some of the data processing applications that he typical large company has successfully developed. All these application areas ave been attacked, one by one, and converted to automatic processing quipment. As a class, these applications have provided the capability of rocessing the massive volume of accounting transactions of an organization, and roducing, as a result of this processing, reports scheduled according to some re-determined cycle.

This is by and large what companies have been doing up to now. The concept hat has been arousing increased interest in recent years has to do not only with he processing of information by computers for accounting purposes but with ısing this same information in different and more imaginative ways. This nvolves, for one thing,, the use of information for management *control* ɪurposes. Here the emphasis is not on historical record-keeping but on the

Reprinted from *Datamation*, vol. 13, pp. 22-27, May, 1967. Reprinted by permission from F. D. Thompson Publications, Inc., 35 Mason St., Greenwich, Conn. Mr. Head is the founder of Software Resources Corporation and is a frequent contributor to the data-processing literature.

FIGURE 1 MANAGEMENT INFORMATION SYSTEM



processing of information requests and the providing of reports "as-required" on a demand basis. The upward-pointing arrows in Fig. 1 are meant to suggest that the same data obtained for routine accounting purposes can be selected and transformed for such management control purposes.

At a higher level of management usage, there is the opportunity, and attendant design objective, in an information system to use the same data not only for middle management control but to aid policy-level decision-makers. The apex of the Fig. 1 diagram suggests that special requests can be directed to the information system by executive management, with the system providing support for decision making at this level.[1] This can be defined as a *planning* type of usage of the information system.

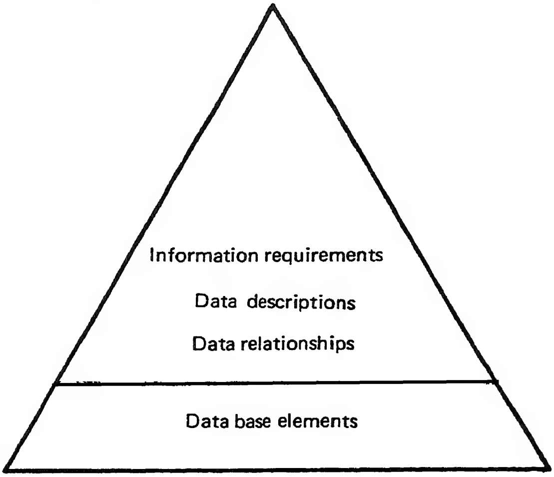
Thus we are evolving from conventional or traditional applications to the use of the same information at the middle management level for control purposes and at the general management or executive level for planning purposes.[2]

[1] Note the phrase "support for decision-making." This is employed deliberately to avoid the implication that the computer itself is a decision-maker in any important respect. While it is true that many lower order decisions have been programmed for the computer (e.g., inventory replenishment), the computer's primary role in a management information system is to provide data adequate to abet the decision-making function. For a general discussion of programmed and nonprogrammed decision-making, see Herbert A. Simon's *The New Science of Management Decision*, (Harper & Brothers, 1960).

[2] Although the terminology differs, the usages of information discussed in this paper generally correspond to the levels of planning and control identified by Robert N. Anthony in his authoritative work, *Planning and Control Systems: A Framework for Analysis* (Harvard, 1965). Anthony's three levels are defined as follows:

Strategic Planning: the process of deciding on objectives of the organization, on changes in

FIGURE 2 MANAGEMENT INFORMATION SYSTEM
DATA BASE



Many practitioners refer to the information identified at the bottom of Fig. 1 as the organization's data base. Another way of looking at this data base is to think not in terms of separate or discrete applications but instead to view the data base as consisting of *elements* of information as shown in Fig. 2. The bottom of this figure can be likened to a "soup" in which numerous data elements are floating around, not well-structured or well-organized but all present. In a large system, there may be hundreds or thousands of different kinds of data elements floating around in this data base soup.

In order to accomplish anything useful with these elements, it is necessary to give the data base an organization and structure. This structuring requires at least three things to be done: one is that the *information requirements* of management have to be identified. We need to know which of the elements potentially available are actually required. We need then to define them by providing a *data description*, in technical terms, of the data elements: how large they are, what their meaning is, where they are stored, how one can get at them.

---

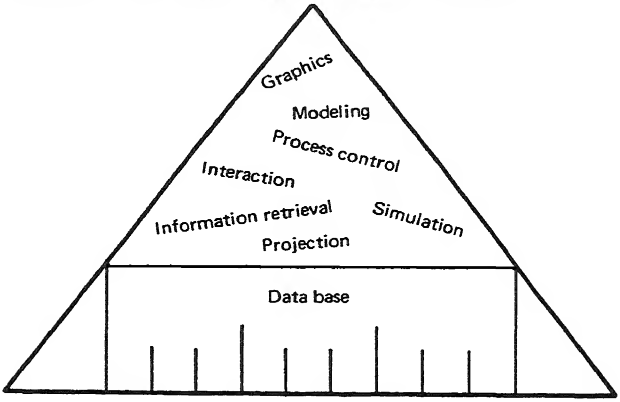
these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources.

Management Control: the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives.

Operational Control: the process of assuring that specific tasks are carried out effectively and efficiently.

From the point of view of this paper, business data processing has heretofore concentrated on accomplishing the specific day-to-day tasks of the company, i.e., operational control.

FIGURE 3 INFORMATION SYSTEM UTILIZATION



Then finally, it is of great importance to identify *data relationships* among the data base elements. An employee skill number might, for example, be a data element. This data element would be referenced in payroll compilation, the maintaining of personnel records, in industrial relations. Thus the same data element could be related to many different files or, putting it another way, to many different management usages of information.

Not only is the organization of information changing significantly from what it has been in the past but the utilization of this information is also changing. Companies engaged in developing management information systems are going beyond the use of computers simply to maintain records; they are exploring much more imaginative and ambitious applications. A few of these new uses are identified in Fig. 3. They include graphics capability to display the elements retrieved from the data base, as well as modeling and simulation. They extend to linking the information system to other systems dedicated to on-line process control, and involve the application of specialized retrieval techniques to pull information from the data base. Most of these innovations in information systems encourage, and in some instances require, a close interaction between manager and machine.

CONSIDERATIONS IN SYSTEMS DESIGN

A fundamental question confronting the system designer when he begins to think about the data base aspect of management information systems is: how many levels of data base are there going to be in the organization? There exists, of course, a management hierarchy with different information needs at its various levels, and so the question arises whether the information system can serve all these levels in an organization with but a single data base.

The bottom of Fig. 4 reflects the continuing need to maintain the details of each business transaction, facts having to do with individual customer accounts and kindred information. All these details of transactions still have to be maintained much as they have been in the past, and information about them will typically constitute a fundamental part of the data base. Operating management obviously does not need all this detail, but it does need some portion or subset of it, as indicated by the center section of Fig. 4. And at the top, policy management needs yet another subset of the overall data base. So the question must be answered: can these varying needs be served by a single data base, or will the system designer be forced to structure three different data bases? If he has to fragment the information system by level, then there is necessarily going to be some redundancy in the data elements maintained. Consider a specific example. In a commercial banking system it is necessary for the teller to have access to the details pertaining to each account—i.e., the current balance, the amounts of the checks drawn against the account, and so on. But this is really not of interest at the operating management level. This level is interested in cumulative information about groups of accounts, say all those under a branch manager's supervision. And at the policy-management level, the information needs are even broader, having to do with loan-to-deposit ratios, and deposit growth expectancy. Thus the designer is confronted with the problem of structuring the data base to accommodate these varying levels of information seekers.

A similar problem, but one having a "vertical" rather than a "horizontal" nature, is suggested by Fig. 5. For not only does the system designer have to structure horizontally, but he has also to determine whether different functional portions of the company can share a common data base—i.e., whether he must chop the data base into vertical as well as horizontal segments. Can the marketing department use the same data base as the production or accounting

FIGURE 4 HOW MANY LEVELS OF DATA BASE?

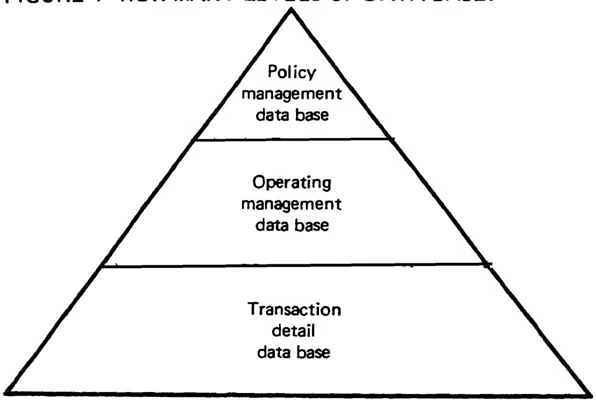
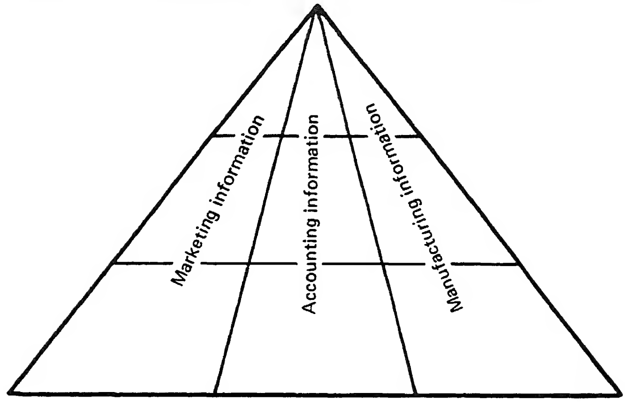


FIGURE 5 HOW MANY SPECIALIZED DATA BASES?



people, or is each intent on having one of its own? There seems to be some tendency in the latter direction, as there exist today systems dedicated, for example, to marketing information and serving the marketing part of the organization only. A major challenge to the information system designer lies in trying to integrate the company data base so that it can be useful to all major organizational levels and components.[3]

Another difficulty confronting the system designer concerns management's "information threshold." This has to do with the level to which a given executive may want to descend into the data base for information. The top horizontal line in Fig. 6 indicates what the system designer may regard as the "appropriate" information threshold for policy-level management. Executive "A", however, does not want to be confronted with the degree of detail envisaged in such a system design. An example that comes to mind is that of General Eisenhower. When he was President, his preference was said to lie in having all problems brought to him summarized very succinctly. Thus, he might

[3]Anthony takes a pessimistic view with respect to the satisfaction of top management's information needs. After asserting, rightfully, in this author's opinion, that "the data needed for strategic planning depend on the nature of the problem being studied" and that "not all these problems can be forseen," he concludes:

It is because of the varied and unpredictable nature of the data required for strategic planning that an attempt to design an all-purpose internal information system is probably hopeless. For the same reason, the dream of some computer specialists of a gigantic data bank, from which planners can obtain all the information they wish by pressing some buttons, is probably no more than a dream.

The author of this paper is more optimistic, holding the view that contemporary data base design concepts, which facilitate the retrieval of data elements in response to unstructured and non-predetermined management requests, can contribute significantly to the realization of such a dream.

be representative of that kind of chief executive who does not want to delve very far down into the data base, but instead desires summary presentations of information.

But if the system is developed to accommodate such an executive's information threshold, the system designer must determine what should be done when his chief is succeeded by another executive who has an entirely different information threshold. Consider executive "B" in Fig. 6, who frequently wishes to examine information that has to do with day-to-day control of the business—i.e., operating data. Secretary of Defense McNamara is regarded as this type of executive in that he has a very low information threshold and demands many detailed facts before making a decision.

Now, the systems analyst does not want to have to restructure, and more importantly, reimplement, the system each time there is a transition from one chief executive to another. He wishes instead to have, as a design objective, a system that is sufficiently *adaptable* to accommodate the information needs of different types of executives. This is certainly another of the challenges in information systems design.

An additional aspect of this information threshold problem, or perhaps another way of looking at it, becomes evident when executive "A" has, let us say, a marketing background, so that when marketing transactions are involved he wants to go all the way down to the bottom of the data base as evidenced by the shaded left hand portion of Fig. 7. Such an executive may call for all the details of a particular customer order, asking "How long was this order delayed?" "What was the amount of the order?" Management experts may assert that this executive is violating sound organizational principles by doing so, but the systems man must recognize that in a real life situation this is the way

FIGURE 6 THE INFORMATION THRESHOLD PROBLEM—I

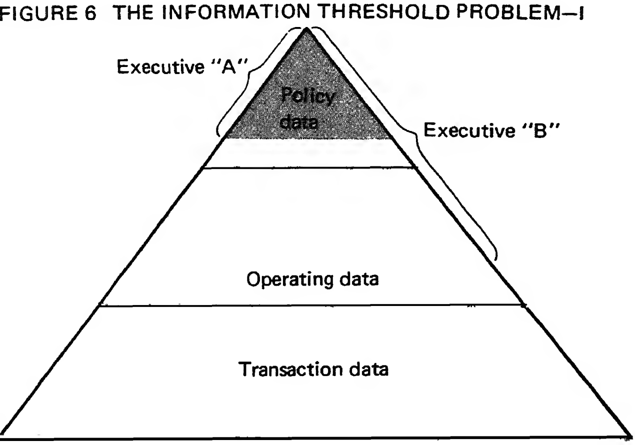
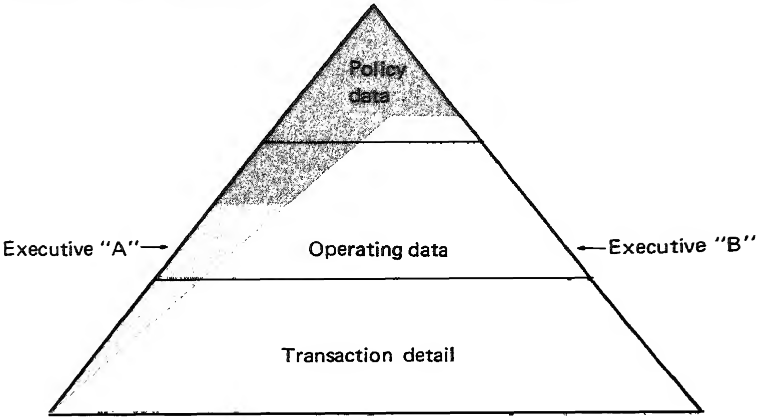


FIGURE 7 THE INFORMATION THRESHOLD PROBLEM—II



executives operate and, consequently, he must design systems to accommodate these needs. Otherwise, management simply will not make use of the system.

And, of course, systems can be tailored in this manner. The designer can allow hypothetical executive "A" to satisfy his personal need to know, but it must be remembered that this executive is not going to be in charge forever and may be succeeded by someone from, say, the engineering sector. This could turn out to be executive "B", as represented by the shaded right hand side of Fig. 7, who in general wishes much more detail, but will want to go down to the very lowest level in the data base only when engineering or R & D problems are involved. It is essential to design a system that does not have to be re-worked completely when such changes in management information thresholds occur.

These are some of the considerations that systems people must be concerned with, whether they work for an equipment manufacturer interested in seeing his equipment used in an information systems context, or for a user seeking to install an up-to-date management information system.

TRENDS

Now that we have established a conceptual framework, let us examine some current industry developments. What are companies actually doing today? Some of the concepts just presented have been in the public domain for some time, but do not necessarily or entirely reflect what is actually happening in terms of the things companies are spending good money on in the information systems field.

APPLICATIONS RE-WORKING Commercial applications programmed in the past are today being re-worked by many companies in a very

drastic and far-reaching way. Existing applications are being redone, not so much because of a conscious decision by management to develop an integrated information system but simply because third-generation computers are being widely installed. Most companies that had in the past a tape-oriented, second-generation computer are now installing larger, third-generation gear. This third-generation equipment offers features not readily available to system designers in the past, including mass direct access storage, a variety of on-line terminal devices, and substantial remote processing capability.

Though it is usually possible for a company to retain existing applications by using emulation or simulation, most companies recognize that they can best exploit the more powerful new computers by rethinking their applications from the bottom up. And in the course of such rethinking, there is an unprecedented opportunity to provide more effectively for the information needs of management. Thus, the fact that new equipment is forcing applications to be redone is giving impetus to the development of management information systems.

FORMALIZED SYSTEMS PLANNING Accompanying, and related to, the phenomenon of applications re-working is the growth of a formalized approach to systems planning. This is largely a reflection of the experience gained in the recent past, when a computer was installed in the company initially for one purpose—to automate the major accounting routines. Thus, public utilities first automated revenue accounting and insurance companies, premium accounting. But now that they have committed themselves to the expensive and time-consuming task of re-working their key applications, companies have become interested in devising some sort of "road-map" of the future in order to avoid yet another wave of re-work a few years hence. A five-year planning period is typical, although some go out longer. All seek to anticipate the systems capability that should exist in the organization over the planning period.

These plans are truly formalized, documented and presented to management for endorsement and reviewed and updated periodically. If, for example, a company has no *corporate* planning staff, the information systems group trying to develop a long-range systems plan lacks the necessary guidance to establish its plan. For the systems plan depends importantly on the firm's overall strategy concerning such matters as new products, mergers and acquisitions, and geographic expansion. When management's own insight into these future possibilities is not clear, the systems group can only build its long-term plan on *assumptions* about company growth. And by so proceeding, the systems people tend to become, by default, the corporate planning staff.

MANAGEMENT SCIENCE EMPHASIS As the focus of technological interest in many companies comes to bear on management information systems, there is heightened emphasis on the employment of management science techniques—i.e., the usage of the computer in a scientific approach to business

problem solving. Looking at this development in historical perspective, it is evident that, with the repetitive accounting tasks already automated, further exploitation of the computer must draw heavily upon statistical and mathematical techniques to assist management decision-making. It is not by accident that some of the major computer manufacturers have moved to unify their product line, bridging the traditional distinction between so-called "scientific" data processing, using binary machines, and "commercial" data processing, using decimal machines. These manufacturers are striving to supply equipment that can be applied to whatever purposes are appropriate for business usage at this point in time.

REGIONAL INFORMATION PROCESSING The design philosophy associated with the development of a broadly applicable company data base would appear to provide a stong motivation towards centralizing the company's information processing systems. In practice, though, there is a tendency to regionalize data processing capability, with a number of large companies proceeding actively along these lines. One diversified manufacturing company presently has data processing capability located in more than 25 decentralized operating departments. These departments, each of which has profit and loss responsibility, in the past had pretty much of a free hand to determine their data processing equipment needs. This company now plans to centralize its computing equipment, though not to the extent of pooling it in one headquarters location. There will be instead four regional centers, serving groups of these decentralized departments.

Another example is that of a large bank that presently operates several centers for processing checks, handling hundreds of thousands of items per day. They are now in the process of closing these centers, but will not pull everything into the bank's headquarters. Instead, this bank will convert to two regional centers.

Why take a regional approach? Perhaps management is reluctant at this time to make the ultimate commitment of concentrating all its data processing capability in one place. Possibly what is now happening represents an intermediate step, and another generation of systems technology will see further centralization.

INFORMATION MANAGEMENT SYSTEMS Concentration on management information systems has encouraged an important collateral effort to develop "information management systems." Some practitioners call these "file management systems," others call them "management inquiry systems," or "data base systems." Basically, an information management system is a software tool useful in organizing, processing, and presenting information. Companies engaged in developing management information systems are showing increasing interest in these programs which help organize and manage information more effectively. Recalling the notion of the data base as a "soup," with data elements floating

around in it, the role of an information management system is to coalesce these data elements into records and files suitable for processing and inquiry purposes. The concept of an information management system is of sufficient importance to warrant a brief discussion of the functions performed by such systems.

SYSTEM FUNCTIONS

File Creation Perhaps the most basic thing they can do is establish files. This involves the identification of the data elements that must appear in a given file. These elements are described to the information management system, which then creates files in accordance with stated requirements for data element and file usage. Storage allocation is controllable by the system, and a file can be set up in whatever physical storage medium is appropriate to the use of the information in the file.

File Maintenance Another of the classical tasks in data processing now being assumed by information management software is file maintenance. Here, transaction processing requirements set forth by the systems analyst are transformed by the information management system into routines to accomplish the updating of master files.

Report Generation The idea of using software to assist in generating management reports is not new. Report generators have been around for a long time, but today's information management systems incorporate them as a function within an integrated and internally consistent software package. Thus, having set up a file and introduced transactions to update that file, the analyst can now direct the system to generate reports tailored to management specifications.

On-Line Inquiry The three information management functions just mentioned would be adequate for conventional, off-line, sequential processing. Many information management systems go beyond this, however, to permit operation in an on-line mode. The files established and maintained by the system thus are made available for direct management inquiry. Such inquiry capability requires the design of an inquiry language and the development of interpretive programs to analyze the inquiries and set up the file search logic required to obtain the data elements needed to satisfy the inquiry.

Information Retrieval The final major function of information management software has to do with information retrieval. If a system is to accept real-time queries against the data base, it is necessary to structure the files in such a way that the system can be immediately responsive to requests for information. Information management systems are thus beginning to borrow from the field of information retrieval. As a consequence, information retrieval techniques have begun moving out of the field of library science and

into business organizations as an important part of information management software.

Consider the difference between the rigidly structured and carefully prescheduled computer reports that management is now accustomed to receiving, and the capability of asking the system to retrieve and display, in real-time, answers to such queries as the following: "Which branches in our banking system have more than 2,000 loan accounts *and* a loan-to-deposit ratio of 1:2 *or* have more than 10% of their deposit accounts with an average of over $10,000." Advanced information management software can help the designer provide this kind of inquiry and information retrieval capability.

PROBLEMS IN SYSTEMS PLANNING

Thus far we have discussed some key notions in information systems design and looked briefly at major developments taking place in leading companies. While these provide signs of substantial progress, many serious problems remain. The list of problems is perhaps not quite so long as it was before the advent of third-generation computers, with their mass direct access storage and inquiry devices. Similarly, the type of software technology epitomized by the new information management systems has helped markedly. The problems remaining are less technical in nature than before. They have to do with introducing the technology that has become available into the company environment.

The most immediate problem of this kind centers around the fact that management information systems cost more than predecessor systems. If a company president studies his system costs, he will soon discover that the equipment and software necessary to support a management information system cost a lot more than the company had to invest in the past in more conventional applications. It is undeniable that there is a higher price tag associated with management information systems than the already considerable cost burden that companies have been carrying for data processing technology. Despite the fact that unit costs have been declining, e.g., cost per bit stored, cost per item processed, hardware and software costs are both rising in an absolute sense, reflecting the more ambitious objectives of today's information systems design. As a result, mamagement is taking a closer look at new equipment proposals, and challenging each new systems project more vigorously.

Associated with the problem of rising developmental and operating costs is that of system justification. Even though a proposed system may be very costly, an enlightened company management may be willing to support it if the proponents of the system can demonstrate what the benefits are going to be. In the past, when a computer was installed for repetitive accounting tasks, there were almost invariably demonstrable savings resulting from clerical worker

displacement. This was usually a very tangible cost-justification, and most companies are proud of the fact that they have been very objective and have never installed a computer without the off-setting cost benefits. But this approach is no longer appropriate for companies that have *already* obtained these tangible cost benefits by means of systems presently installed. Today, the question is not what it may be worth, for instance, to an investment company to update its portfolios and otherwise process the paperwork, but rather what it is worth to provide an investment manager with a cathode-ray tube display device and the underlying mathematical techniques to aid in security analysis and portfolio selection. These are benefits that in the past were referred to, a trifle cavalierly, as "intangible." But *most* of the benefits of a management information system are of this intangible nature. Clearly, what is needed are new methods of justifying information system costs by quantifying somehow these heretofore "intangible" benefits. Until this can be done, it is difficult to see how management can be persuaded to commit substantial company resources to truly effective information systems development.

In seeking to chart a course of action, management men sometimes become understandably confused about just what their systems people are trying to do in the field of information technology. All too frequently management is caught in the crosstalk between two schools of thought: on the one extreme there are the enthusiasts, who point to the very powerful and sophisticated results that can be obtained with computers. It is easy, they assert, to develop a management information system. If only a particular piece of hardware is purchased or software applied, you are well on the way to achieving tremendous progress. There has unquestionably been a great deal of overzealousness, and overselling, but at the other extreme lies undue disillusion. There are people who say: "This is all baloney. There really is no such thing as a management information system, it is a sort of chimera. We must be more practical and abandon these grandiose concepts." And management has been caught in the middle.

Also contributing to management's difficulty in trying to understand information systems technology is the communications gap that frequently exists between the systems professionals in the company and the management people responsible for determining where the company is going in information systems. This communications gap has always existed, but it has become more evident now that it concerns systems that have an immediate impact on decision-making. These are foremost among the problems associated with the introduction of management information systems. While much has been accomplished in the technological sphere and in the refinement of important concepts, much remains to be done before these systems become operational on a broad scale. The challenges to be faced are many, and the exploitation of the technical tools now available will require the best efforts of systems professionals, coupled with an unprecedented level of management support.

READING 10 DISCUSSION QUESTIONS

1 Why are data descriptions and data relationships important?

2 "Another difficulty confronting the system designer concerns management's information threshold." What does this statement mean?

3 (a) What trends does the author see in the current development of information systems?
(b) Comment on each of these trends.

4 (a) What functions are performed by information-management systems?
(b) Is there any basic difference between "information-management systems" and "file-management systems"?

5 What problems in systems planning are identified in this article?

SUMMARY OF CHAPTER 2

Revolutionary changes are now taking place in information-processing concepts and techniques. Rapid developments in scientific, social, and economic areas have stimulated and contributed to significant changes in computer hardware and software since 1960.

Hardware advances include (1) substantial reduction in the size, weight, and cost of equipment compared with the same features of earlier machines; and (2) significant increases in processing speed and storage capacity. Advances in software include (1) more efficient and effective translation programs, (2) the development of better applications packages, and (3) the creation of sophisticated multiprogramming concepts and complex operating systems. One result of improving computer technology has been the rapid growth in the number of computer installations; another result is the severe shortage of technical personnel.

Because of the unprecedented scope and pace of environmental changes, the business manager must be prepared to make continuous readjustments in his plans. He must make more and better decisions about markets, products, and matters of finance. Furthermore, he must make these decisions within a time span which is constantly shrinking. Such decisions require information of the highest possible quality.

As a result of difficulties experienced with traditional information-processing techniques, businesses have developed (and are currently working on) quicker-responding and more-integrated systems to meet the informational needs of managers. These emerging management information systems can provide many benefits; but they can also present problems to managers who are not prepared to cope with the managerial implications of computer usage.

COMPUTER IMPLICATIONS FOR MANAGEMENT: AN ORIENTATION

The purpose of this chapter is to provide a broad orientation to the managerial implications of computer usage. Some implications, of course, have been suggested in previous chapters. For example, the ability of a manager to access online files in search of answers to queries carries definite planning and control overtones. In this chapter we shall first briefly summarize the *functions of management*. We shall then gain an overall perspective on the remaining chapters of this text by looking at the impact which the introduction and use of computers can have in the areas of *planning and making decisions, organizing, staffing,* and *controlling. Economic implications* will also be considered.

MANAGEMENT FUNCTIONS

What is management? For our purposes, *management* is defined as the process of achieving organizational objectives through the efforts of other people. Three important points of this definition may be emphasized. The first point is that management is a *process*—i.e., *management consists of a number of interrelated steps or functions* which, when satisfactorily performed, lead to the achievement of goals. The second point is that without the establishment of specific objectives, the effective practice of management is most difficult, if not impossible. The third point is that the successful practice of management involves people working together in harmony to achieve desired results. The availability of quality information is, of course, a requirement for a smoothly functioning operation.

The business manager is a practitioner of the art and science of management. It is his job to carry out the basic management functions necessary to attain company goals. Of course, the objectives pursued vary according to the manager's mission; however, the functions of *planning, organizing, staffing,* and *controlling* are performed by all managers.[1]

[1] This is not necessarily an exhaustive list of all the functions performed by managers. It is, rather, an outline of those functions which we shall be referring to in this text.

PLANNING

The planning function looks to the future; to plan is to decide in advance a future course of action. Thus, *planning* involves making decisions with regard to (1) the selection of both short-run and long-run business strategies and goals; (2) the development of policies and procedures which will help accomplish objectives or counter threats; (3) the establishment of operating standards which serve as the basis for control; and (4) the revision of earlier plans in the light of changing conditions. The steps followed in *planning and in arriving at rational decisions are:*

1 *Identifying the problem or opportunity.* Meaningful planning may begin when a manager understands and has correctly defined the problem or opportunity which he faces. Information is needed to bring about awareness.
2 *Gathering and analyzing relevant facts.* To plan and make decisions, managers must have information which possesses the desirable characteristics outlined in Chapter 1.
3 *Determining suitable alternatives.* The manager must seek out the most attractive possible courses of action. The appropriateness of the options selected is determined by the manager's skill and by the quality of his information.
4 *Evaluating and selecting the most appropriate alternative.* The manager must weigh the options in light of established goals and then arrive at the plan or decision which best meets the company needs. Again, the correctness of this choice depends upon managerial skill and information quality.
5 *Following up on decision.* Broad plans may require supporting supplementary plans. For example, if the result of the above steps is a decision to acquire a computer, then additional plans must be made (a) to locate the new computer department in the organization, and (b) to staff it with operating personnel.

ORGANIZING

The organizing function involves the grouping of work teams into logical and efficient units in order to carry out plans and achieve goals. In a manufacturing company, employees may be grouped formally into production, marketing, and finance divisions. In each of these divisions, workers may be further organized into smaller units. The marketing division, for example, might consist of advertising, direct selling, and marketing research departments. Salesmen might be further organized by territory, by products sold, and by type of customer contacted. Managers at each organizational level receive formal authority to assign goal-directed tasks; they then must motivate and coordinate employee efforts if goals are to be achieved. To sum up, *organizing* is "the grouping of activities necessary to accomplish goals and plans, the assignment of these

activities to appropriate departments, and the provision for authority delegation and coordination."[2]

STAFFING

One aspect of the *staffing* function consists of selecting people to fill the positions which exist in the organizational structure of the business. The staffing activity also includes (1) the training of employees to meet their job requirements, (2) the preparation of employees for promotion to positions of greater responsibility, and (3) the reassignment or removal of employees when such action is required.

CONTROLLING

Unlike planning, which looks to the future, the *control* function looks at the past and the present. It is a follow-up to planning; it is the check on past and current performance to see if planned goals are being achieved. The *steps in the control function are:*

1 *Setting standards.* Proper control requires that predetermined goals be established by planners. These standards may be expressed in *physical terms* (e.g., in units produced, in quantities sold, or in machined tolerances permitted) or in *monetary terms* (e.g., in the form of operating-cost budgets or sales-revenue quotas). The setting of realistic standards requires quality information.
2 *Measuring actual performance.* Timely and accurate performance information is essential to control.
3 *Comparing actual performance with standards.* Comparison information is action oriented. Computers can provide this information to managers on an *exception basis only* when performance variations are outside certain specified limits.
4 *Taking appropriate control action.* If actual performance is not up to the standard, it may be because the standard is unrealistic. Therefore, replanning may be necessary to revise the standard. Unfavorable performance may have to be corrected by reorganizing work groups or by adding more employees. Thus, the control actions taken may require further planning, organizing, and staffing activities. If outstanding performance is noted, the appropriate action may be to reward the individuals or groups responsible.

The process of management is a continuing one. The *order* of the four managerial functions presented here (planning, organizing, staffing, and controlling) is a logical one and we shall use this order as the basis for the

[2] Harold Koontz and Cyril O'Donnell, *Principles of Management,* 3rd. ed., McGraw-Hill Book Company, New York, 1964, p. 205.

presentation of the material in the next four chapters. In practice, however, managers carry out these functions simultaneously. "Plans beget subordinate plans, old plans require modifications, and new plans develop while old ones are in effect. Thus, it is impractical to insist on a special time sequence for the various functions."[3]

MANAGERIAL IMPLICATIONS OF COMPUTERS

We saw in Chapter 1 (and in Figure 1-3) that quality information could support good decisions; good decisions should lead to effective performance of managerial functions; and effective functional performance should lead to the attainment of organizational goals. It is not surprising, therefore, that the acquisition and use of a computer (or any tool which promises to dramatically improve the quality of information) may have important managerial implications.

PLANNING AND DECISION-MAKING IMPLICATIONS

We can consider this broad topic from at least three viewpoints. *First*, it is possible to look at the implications involved in *planning for computers. Second*, we can look at the impact of *planning with computers*. (Planning *for* computers should not be confused with planning *with* computers. The first subject deals with the *introduction* of the system; the latter deals with its subsequent *use*.) Finally, we can look at the computer-oriented *decision-making techniques* which are now gaining acceptance.

PLANNING FOR COMPUTERS In light of the importance of information in the decision-making process, it would be logical to assume that top executives have always actively participated in the planning and implementation of new systems which would influence their future decisions. Alas, such leadership has often been lacking! A study conducted a few years ago by the management consulting firm of McKinsey & Company concluded that no company achieved above-average results without the active participation of top executives. The study further pointed out that 18 of 27 of the nation's *largest* computer users obtained results which, at best, could only be described as marginal.[4] Other studies conducted in the past have arrived at similar conclusions.

[3] *Ibid.*, p. 39.

[4] See John T. Garrity, *Getting the Most out of Your Computer* (New York: McKinsey & Company, Inc., 1963). The reading entitled "Unlocking the Computer's Profit Potential" at the end of this chapter is a second research report on the computer conducted by McKinsey & Company. In this recently published study of 36 major firms, it is observed that, with few exceptions, the mounting computer expenditures of the companies studied are no longer matched by rising economic returns.

In short, many executives apparently felt that the introduction of a computer was primarily a technical problem. They were content to define the goals of the new system vaguely and then to turn the entire project over to data-processing specialists. Such abdication ignored the far-reaching personnel and organizational implications of the undertaking. Without precisely defined managerial information needs and without the backing at the top echelons which is often required to secure cooperation and overcome resistance to procedural and organizational change, the specialists could be excused if their efforts resulted in marginal results.

Top managers should realize that their serious involvement in planning for computers is perhaps the most important single factor determining the success or failure of a computer installation. They should also be aware of the magnitude of the problems which will have to be overcome. Firms which have been successful in making computers pay off have been thorough in the initial planning stages. A careful *feasibility study* (to be covered in Chapter 4) is required to answer such questions as:[5]

1 What data-processing improvements are needed—i.e., what are the data-processing objectives of the firm?
2 Has proper attention been given to systems review and redesign?
3 Is computer usage the best way to achieve all of the objectives? Have noncomputer alternatives been evaluated?
4 Have all computer alternatives been considered? (A firm need not acquire its own machine. The use of computer centers or multisubscriber timesharing services are possible options.)
5 If an in-house installation is justified, have all feasible machines and vendors been considered?
6 Have different acquisition methods (rental, lease, or purchase) been studied?

If, as a result of careful study and planning, a decision is made to order a computer, then the following additional plans must be developed:

1 *Technical preparation plans* Prior to the delivery of hardware, the computer site must be laid out and prepared; initial programs must be written and tested. This subject is also considered in Chapter 4.
2 *Organizing plans* It is important that adequate attention be given to the composition and location of the computer department. The subject of organization and the computer is covered in Chapter 5.
3 *Personnel preparation plans* Staffing plans should be made to fill the new jobs which will be created. For example, the selection and training of programmers should take place without delay so that they may begin

[5] Much time must be spent in planning for an initial computer installation. As much if not more time may be required to convert to other machine models. Most of the questions and types of plans indicated below will reappear for consideration in a later conversion.

preparing the initial programs. Plans should also be made to alleviate the hardships brought about by the elimination of jobs. These personnel topics are developed further in Chapter 6.

4 *Control plans* The quality of the information produced must be controlled. The accuracy of input data must be considered. And internal controls should be created to minimize error and disclose fraud when and if it occurs. The subject of computer controls is considered in Chapter 7.

PLANNING WITH COMPUTERS. Information played an important part in the successful completion of each of the steps in the planning procedure which was presented earlier. Generally speaking, computer usage can improve planning by providing effective information which (1) leads to problem awareness, (2) supports problem analysis and selection of alternatives, (3) influences the choice of the most appropriate option, and (4) permits feedback on the implementation of decisions.[6] More specifically, *the use of computers can have an impact on the planning function by:*

1 *Causing faster awareness of problems and opportunities* Computers can quickly signal out-of-control conditions requiring corrective action when actual performance deviates from what was planned. Masses of current and historical internal and external data can be analyzed by the use of statistical methods including trend analyses and correlation techniques in order to detect opportunities and challenges. Planning data stored online may permit managers to probe and query files and receive quick replies to their questions.

2 *Enabling managers to devote more time to planning* Use of the computer can free the manager of clerical data-gathering tasks and permit him to concentrate more attention on analytical and intellectual matters. The computer is an intelligence amplifier which broadens man's time dimension.

3 *Permitting managers to give timely consideration to more complex relationships* The computer gives the manager the ability to evaluate *more* possible alternatives (and to consider *more of the internal and external variables* which may have a bearing on the outcome of these alternatives. It makes it possible for managers to do a better job of identifying and assessing the probable economic and social effects of different courses of action. The awareness of such effects, of course, influences the ultimate decision. In the past, oversimplified assumptions would have to be made if resulting decisions were to be timely. More complex relationships can now be considered and scheduled. In addition to broadening man's time dimension, the computer can furnish him with planning information which could not have been produced at all a few years ago, or which could not have been produced in time to be of any value.

[6] An excerpt from Richard G. Canning's *EDP Analyzer* entitled "Trends in the Use of Data Systems" appears at the end of this chapter. It presents an excellent discussion of computer-assisted corporate planning.

4 *Assisting in decision implementation* When decisions have been made, the computer can assist in the necessary development of subordinate plans which will be needed to implement these decisions. Computer-based techniques to schedule project activities have been developed and are now widely used. Through the use of such techniques, business resources can be utilized and controlled effectively.

Computer usage can certainly improve the effectiveness of managerial planning. But before leaving the subject of planning with computers, it should be emphasized that computers *do not* "make decisions." Rather, they follow program decisions made earlier by managers and programmers. Although experiments are being conducted by extremely able researchers attempting to improve the machines' ability to solve ill-structured problems, it is man and not machine who performs the judgmental part of problem solving. It is man who defines problems, selects strategies to follow, and formulates hypotheses and hunches. *Heuristic* is a word which means "serving to discover." Much of planning is judgmental or heuristic in nature, and man is far superior to machine in the heuristic area of intellectual work.[7]

DECISION-MAKING TECHNIQUES A number of quantitative managerial aids have been introduced which utilize computers to provide the framework for decision-producing analyses. These techniques (which are often classified under the headings of *operations research* or *management science*) can be used to (1) speed up problem or opportunity awareness, (2) permit more timely consideration of increasingly complex relationships, and (3) assist in decision implementation. In particular, the computer-based techniques of *network analysis,*[8] *mathematical programming, and simulation* have managerial implications.

NETWORK ANALYSIS Both PERT (*P*rogram *E*valuation and *R*eview *T*echnique) and CPM (*C*ritical *P*ath *M*ethod) are network models which are used to plan, schedule, and control complex projects. The basic concepts of PERT and CPM are similar.[9] The following procedure is used to set up a network model:

1 *All* the individual *activities* to be performed in the project must be identified.
2 The sequence of each activity must be determined—i.e., it must be known what elements have to be completed prior to the start of a particular activity and what tasks cannot commence until after its completion.
3 The *time interval* required to complete each activity must be estimated.

[7] At the end of this chapter is a reading by Peter Drucker which places the computer's role in planning in proper perspective.

[8] For a detailed presentation of this subject, see Philip L. Blumenthal, Jr., "Network Analysis," *Journal of Accountancy,* January, 1968, pp. 77-80.

[9] They differ in that CPM uses one activity–time estimate while PERT incorporates "optimistic," "pessimistic," and "most likely" activity-time estimates.

4 The *longest sequence* of events in the project must be identified. The sum of the individual activity times in this sequence becomes the total project time, and this sequence of activities is known as the *critical path.*

Network models have gained widespread acceptance. The Department of Defense requires that they be used on all major defense contracts, and major construction projects employ them. They have proven quite effective in helping manage the transition to computer data-processing systems. The use of PERT and CPM improves the *planning* function because it forces managers to identify *all of the project activities which must be performed. Control* is also improved because attention can be focused on the sequence of activities in the critical path. Managers quickly become aware of potential problems. If a critical activity begins to slip behind schedule, steps can be quickly taken to correct the situation. By trading project cost against project time, several alternative paths can initially be computed to help in planning. By a greater commitment of resources, managers can often reduce the time required to complete certain activities in the critical path (and thus reduce total project time). The effect of a greater resource commitment, however, is often higher project cost. Network models can simulate the effects on time and cost of a varying resource mix. Computations for small networks can be produced manually, but a computer is needed with networks of any significant size. Most computer manufacturers have PERT and CPM packaged programs available.

MATHEMATICAL PROGRAMMING[10] The purpose of mathematical programming is to find the best strategy from among a large number of options. Most mathematical programming work involves the use of *linear programming.* Not to be confused with computer programming, linear-programming models are used to find the *best combination* of limited resources to achieve a specified objective (which is, typically, to maximize profit or minimize cost). One important class of linear-programming applications is in blending operations, where the objective is often to minimize the cost involved in the production of a given amount of blended product. For example, cattle feed may be a mixture of minerals, grains, and fish and meat products. The prices of these ingredients are subject to change, so the least expensive blend required to achieve specified nutritional requirements is subject to variation. Linear programming can help managers quickly determine the correct blend to use to minimize cost while meeting product specifications.

In addition to blending, linear programming is being used for such diverse purposes as scheduling manpower, selecting media for advertising purposes, determining minimum transportation costs from given supply points to specified

[10] For more details on this subject, see Thomas B. Glans and Frank H. White, "Linear Programming—'Catching on Fast'," *Journal of Data Management,* April, 1966, pp. 38-41.

points of delivery and determining the most profitable product mix that may be manufactured in a given plant with given equipment. Practically all linear-programming applications require the use of a computer. As a powerful *planning* tool, linear programming enables a manager to select the most appropriate alternative from a large number of options. It is also a technique which may aid the manager in carrying out his other functions. Its use in scheduling manpower, for example, has definite staffing implications.

SIMULATION In the physical sciences, experiments may be performed in a laboratory using small models of a process or an operation. Many complex variations may be possible in these tests, and the results show the scientist what happens under certain controlled conditions. Simulation is similar to scientific experimentation in that managers may evaluate proposed strategies by constructing business models. They can then determine what happens to these models when certain conditions are given. Simulation is thus a trial-and-error problem-solving *approach*; it is also a *planning* aid which may be of considerable value to executives.

Simulation models have helped managers decide, for example, whether or not to expand operations by acquiring a new plant. Among the dozens of complicating variables which would have to be incorporated into such models are facts and assumptions about (1) present and potential size of the total market, (2) present and potential company share of this total market, (3) product selling prices, and (4) investment required to achieve various production levels.

Simulation models are also used to improve inventory management. The problem of managing inventories is complicated because there are conflicting desires among organizational units, and what is best for one department may not be best for the entire firm. To illustrate, the purchasing department may prefer to buy large quantities of supplies and raw materials in order to get lower prices; the production department also likes to have large inventories on hand to eliminate shortages and to make possible long—and efficient—production runs; and the sales department prefers large finished-goods inventories so that sales will not be lost because of out-of-stock conditions. The finance department, on the other hand, views with concern large inventory levels since storage expense is increased, risk of spoilage and deterioration is increased, and funds are tied up for longer periods of time. Through the use of simulated inventory amounts and simulated assumptions about such factors as reorder lead times and cost of being out of stock, managers can experiment with various approaches to arrive at more profitable inventory levels.

In short, we see from this brief summary of simulation that it can aid in planning by permitting managers to give timely consideration to complex relationships. Of course, in many respects there is nothing new about simulation.

As Franklin Lindsay points out:[11]

> *A corporate planner who sets forth half a dozen alternative investment schemes, together with the costs and expected return from each, is simulating each alternative so that his board of directors can judge their relative merits. But the new mathematical tools, together with high-speed computers, extend tremendously the capabilities of simulation processes.*

ORGANIZATIONAL IMPLICATIONS

The organizational framework of a business is structured on the work to be done and on the human and physical resources to be committed. With the introduction of a computer, however, significant changes are likely to be made in data-processing activities and thus in those departments which are engaged in informational activities. When this happens, it is often desirable to restructure the organization in the interests of greater efficiency. Work groups may be realigned; tasks formerly assigned to a number of departments may be eliminated or consolidated in a single new computer department; and existing departments may be eliminated or the scope of their operations may be sharply curtailed. Basic changes of this nature require the attention of top executives.

We have seen earlier that broader information systems are now being designed and implemented. Related to this trend is an organizational issue of fundamental importance. The issue to be decided is to what extent the new systems should concentrate or *centralize* authority and control in the hands of the top-level managers. With a computer, a greater degree of centralized control *can* be supported in a business because top managers can be furnished with information from outlying divisions in time to decide on appropriate action. Without computers, such action must be determined by a lower-level manager because of time, distance, and familiarity factors. But although greater centralized control *can be supported* with a computer, it is *not necessarily a requirement*. The degree of centralized authority and control which *should* exist in the new system is determined by managerial philosophy and judgment and not by computer usage. The impact of the path chosen on future organizational structure, basic company philosophy and policies, and managerial authority of managers below the top echelons will be great. Certainly, decisions of this magnitude require the serious consideration of top executives; they are just too fundamental to be left to data-processing specialists or lower-level managers. We shall look more closely at the questions of computer department organization and the centralization of decision-making authority in Chapter 5.[12]

[11] Franklin A. Lindsay, *New Techniques for Management Decision Making*, McGraw-Hill Book Company, New York, 1963, p. 60.

[12] These topics are briefly treated in Neal J. Dean's "The Computer Comes of Age" and in other readings which appear at the end of this chapter.

STAFFING IMPLICATIONS

Data-processing changes often bring about organizational stress. The introduction of a computer also requires employee adjustments. Staffing decisions are necessary (1) to select and train workers for new jobs (and to then retain these workers) and (2) to deal with employees whose jobs have been eliminated or reduced in content or appeal. Resistance may be expected from employees and managers because of significant changes occurring in the alignment of work groups, in the content of individual jobs, and in the methods of performing data-processing tasks. Proper planning and leadership can reduce this resistance. We shall look into this matter again in Chapter 6.

In addition to considering the implications of filling new jobs and of coping with resistance to change, top executives should also realize that it does no good to attempt to install sophisticated systems if company managers at all levels are unable to (1) define their information needs, (2) develop analytical planning, decision-making, and control procedures, (3) state specifically these analytical procedures, and (4) interpret and make use of the output of the sophisticated systems. If the machines are to be effectively utilized, it will generally be necessary to undertake an educational effort to acquaint managers with computer capabilities and with the analytical tools which will make use of those capabilities.

CONTROL IMPLICATIONS

Several ways in which computer usage can affect the control function have already been pointed out, so we need not dwell long on the subject here. The *control implications of computer usage* include the facts that:

1 Computers can quickly signal out-of-control conditions, thus bringing about faster awareness of problems. Going a step further, programmed analyses may be carried out by the computer to present recommended courses of action to managers.
2 Triggered control reports, based on the *principle of exception,*[13] may be prepared only when actual performance varies from planned standards. Managers are thus relieved of much routine paper shuffling and are freed to concentrate on more important personnel and environmental matters.
3 Computer-based techniques such as PERT and CPM may permit more effective control of business resources.
4 Computer systems make it possible to centralize authority and control

[13] In Chap. 18 of Exodus, Jethro gives good advice when he tells Moses to delegate some of his routine leadership duties to subordinates and to concentrate his attention on the more important exceptions which the subordinates are unable to handle. This idea is called "the principle of exception" in management literature.

previously delegated to lower echelons because of time, distance, and familiarity factors.

5 Internal control and auditing techniques will generally have to be revised to accommodate computer systems. Internal control and auditing will be examined in Chapter 7.

ECONOMIC IMPLICATIONS

From an economic standpoint, the acquisition of a computer cannot be taken lightly. An investment decision involving many thousands (or a few millions) of dollars must be made. It is the duty of top executives to determine if a computer can be justified economically. A computer *can* improve the firm's economic position by reducing the ratio of expenses to revenues in tangible and intangible ways. But there is no guarantee that profits *will* be improved merely because a computer is installed. On the contrary, many firms have invested large sums in computers and have received returns of *less* than a dollar for each dollar spent. (Of course, merely to recover the initial investment is hardly sufficient either, for the money invested in a computer could be put to use in an alternate manner which might prove to be quite profitable.)

Computer acquisition is a difficult capital-investment decision; it must be recognized as such by the top officers in the company. They must also be aware that the level of expenditures initially required is *frequently underestimated* and that this level will probably continue to increase in the years after acquisition.[14] Finally, they must consider the possible economic implications of *not keeping pace with competitors* in the development and use of new information systems.

DISCUSSION QUESTIONS

1 **(a)** What is management?
  (b) What activities or functions must be performed by managers?

2 **(a)** What is involved in the planning function?
  (b) What steps must be followed in planning?

3 Explain what is involved in **(a)** the organizing function and **(b)** the staffing function.

4 Identify and discuss the steps in the control function.

5 **(a)** What is the distinction between "planning for computers" and "planning with computers"?
  (b) What are the managerial implications of planning for computers?
  (c) Of planning with computers?

[14]See the discussion of varying cost patterns in the reading at the end of this chapter entitled "The Computer Comes of Age."

6 What are the managerial implications of computer-based decision-making techniques?

7 (a) Discuss the possible organizational implications of computer usage.

(b) What are the possible staffing implications?

8 (a) What are the possible control implications of computer usage?

(b) The economic implications?

CHAPTER THREE READINGS

INTRODUCTION TO READINGS 11 THROUGH 15

11 This paper summarizes the findings of a McKinsey & Company study of computer systems management in 36 major companies. After noting that from a profit standpoint computer efforts in all but a few exceptional companies are in real, if often unacknowledged, trouble, this reading discusses (1) the past successes and present problems of computer management, (2) the opportunities which may be realized from advanced computer applications, and (3) the keys to successful computer practice.

12 As this article points out, management information systems seem to some executives to be creating more problems than they solve. The conclusion is that thus far information systems development "has been plagued by confusion and missteps."

13 In this reading, Richard G. Canning points out how data-processing staffs are beginning to shift their attention to the development of systems which will directly assist managers in performing their planning and control functions. The topics treated here are (1) computer-assisted corporate planning, (2) fast, flexible reporting, (3) systems integration through use of a corporate data file, and (4) the use of fast-response systems.

14 Peter Drucker's article is a fitting one to include in Chapter 3 because it touches on several computer implications for management. Noting that the computer is transforming the way businesses operate, Professor Drucker also discusses (1) what the computer can and cannot do for the businessman, (2) possible effects on organizational structure and on managers, and (3) future developments in computer usage.

15 This reading reports the findings of a study of 108 manufacturing companies made by the management-consulting firm of Booz, Allen & Hamilton Inc. The article points out that as a result of computer usage (1) a top computer executive has emerged in most of the firms studied; (2) this executive is often responsible for activities other than the computer activity; (3) most firms expect to increase in the future the amount of money being spent in using computers; (4) the trend is away from restricting the computer to finance and administration; and (5) the firms plan to move in the direction of greater systems integration.

READING 11 UNLOCKING THE COMPUTER'S PROFIT POTENTIAL*

McKINSEY & COMPANY, INC.

In terms of technical achievement, the computer revolution in U.S. business is outrunning expectations. In terms of economic payoff on new applications, it is rapidly losing momentum. Such is the evidence of a recent study by McKinsey & Company of computer systems management.

In the course of this study, we interviewed staff and line executives, up to and frequently including the chief executive officer, in 36 large U.S. and European companies from 13 industries, representing all levels of achievement and experience with computers. Their distribution by industry, sales volume, and relative level of computer expenditure is shown in Exhibit 1.

Because the computer practices and achievements of these companies are so diverse, there is little point in trying to formulate quantitative performance measures. As Exhibit 1 indicates, success with the computer shows no consistent correlation with level of computer expenditures. Some companies are spending heavily for a very dubious payoff; others with less ambitious programs are reaping major rewards.

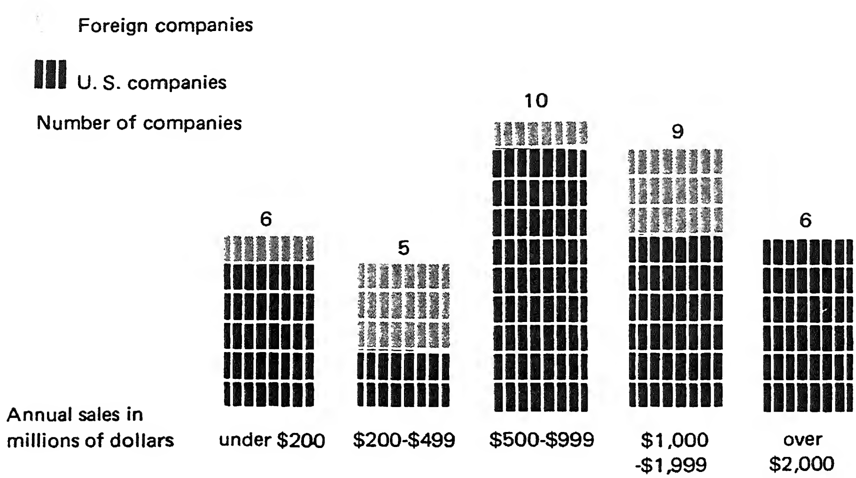
In view of the many variables involved, any absolute standard of computer success must necessarily be arbitrary. In this study, therefore, we decided to let "success" be defined by the range of performance observed in the survey sample itself. Accordingly, the 36 companies were ranked judgmentally on their overall achievement with the computer, taking into account such factors as measurable return on the computer investment over time, range of meaningful functional applications, and chief executive satisfaction with the computer effort to date. Those falling in the upper half of this order-of-performance ranking are the "more successful computer users"; the "less successful" are those in the lower half. Admittedly, there is an element of subjectivity in judgments of this kind. But we believe that any unbiased analyst having access to the same data would arrive at essentially the same results.

From a profit standpoint, our findings indicate, computer efforts in all but a few exceptional companies are in real, if often unacknowledged, trouble. Faster, costlier, more sophisticated hardware; larger and increasingly costly computer staffs; increasingly complex and ingenious applications: these are in evidence everywhere. Less and less in evidence, as these new applications proliferate, are profitable results.

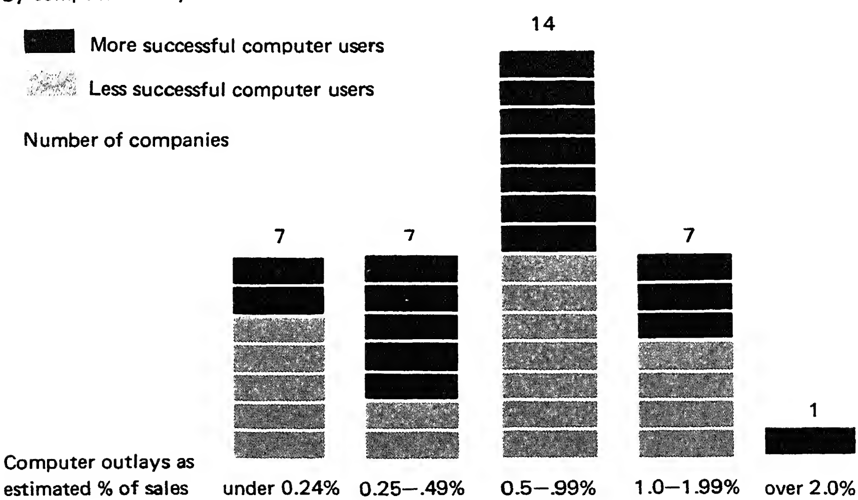
Most large companies have successfully mechanized the bulk of their routine clerical and accounting procedures, and many have moved out into operating

EXHIBIT 1 PROFILE OF THE STUDY SAMPLE

By size of company



By computer outlay



applications. Yet with few exceptions their mounting computer expenditures are no longer matched by rising economic returns.

What has gone wrong? The answer, our findings suggest, lies in a failure to adapt to new conditions. The rules of the game have been changing, but

management's strategies have not. A look at current computer development efforts shows that the prime objective of many is still the reduction of general and administrative expenses. Yet for most companies this is an area of fast-diminishing returns. It is high time for a change of course in the computer development effort, many senior executives are beginning to recognize. "How can I keep on justifying major computer expenditures when I can't show a dollar saved to date from our last three applications?" asks the president of a large consumer goods company.

The hard-to-justify outlays, however, are insignificant compared to the opportunity costs. Though it has transformed the administrative and accounting operations of U.S. business, the computer has had little impact on most companies' key operating and management problems, where its real profit potential lies—a potential that has barely begun to be tapped. Meanwhile the gap between technical capability and practical achievement continues to widen, the stakes keep on rising, and the penalties of lost opportunities and lost profits multiply.

THE STAKES AND THE PROBLEM

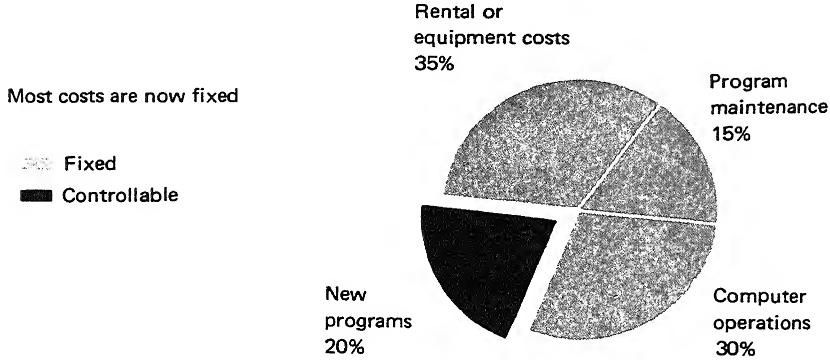
In 1963, computer manufacturers shipped hardware worth $1.3 billion to their U.S. customers. By 1967, the value of computer shipments had risen to $3.9 billion, an increase of no less than 200 percent in four years.[1] For every dollar spent on equipment, moreover, the typical company in our current study spent close to $2.00 on people and supplies last year, as Exhibit 2 indicates; and the payroll component of the total outlay is clearly rising more rapidly than the rental bills.

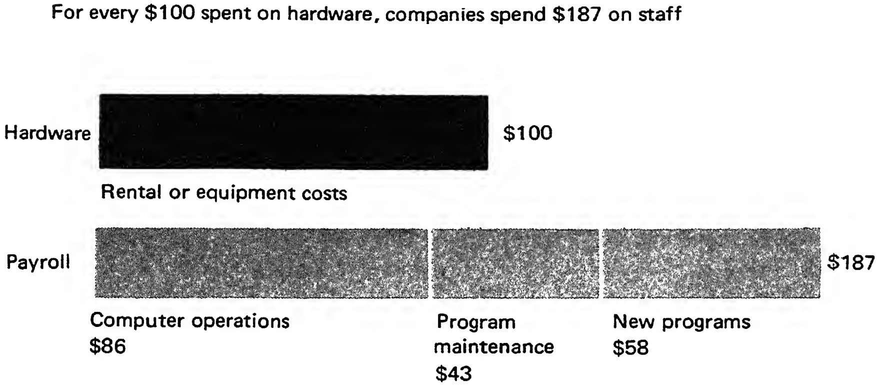
Because so much of the total cost is payroll, and because staffs are dispersed and personnel classifications and accounting conventions differ from company to company, attempts to formulate "yardsticks" for corporate computer outlays (e.g., as a percentage of assets, capital expenditures, administrative expenses, or sales volume) are apt to be misleading. What a particular company "ought" to be spending on computers will not be discovered by studying industry averages or the outlays of individual competitors. In the last analysis it can only be determined in the light of the company's own situation, strategy, and resources, including the depth and sophistication of its computer experience.

Nevertheless, it is true that the distribution of costs which go to make up total computer expenditures is faily consistent among the companies in our study. As Exhibit 2 indicates, about $35,000 out of every $100,000 in total computer outlays goes for hardware; $30,000 for computer operations staff payroll; $15,000 for maintenance programming (i.e., keeping current systems updated);

[1] *EDP Industry and Market Report,* January 16, 1968.

EXHIBIT 2 HOW COMPUTER COSTS ARE DISTRIBUTED





and the remaining $20,000 for development programming and other staff time devoted to new applications.

These development dollars, the only computer outlays subject to significant short-term management control, are typically a smaller fraction of the total than the company's annual bill for hardware rentals. Yet their leverage on future costs and benefits is enormous; in fact, they hold the key to the company's long-range success or failure with its computer effort. For unless management segregates these costs and understands the nature of the resources they buy, the direction of future computer developments will be in doubt and the whole activity will be vulnerable to hasty and perhaps emotional review.

The computer management problem as it confronts corporate executives today, then, is a matter of future direction rather than current effectiveness. The key question is not "How are we doing?" but "Where are we heading, and why?"

Five years ago this was a less critical issue at the top-management level. As long

s computer developments were largely confined to accounting departments here was less reason for corporate executives to concern themselves with lirection setting. If the controller carried out his function and kept his costs in ine, no one outside his department worried very much about *how* he did it. The ituation is very different today. Now that the conversion of accounting work to omputer processing is virtually complete—as it is in 30 of the 36 companies in our study—the question "What next?" comes into urgent focus. Many of the lternatives currently being proposed are complex and costly enough to require xecutive approval, but their justification is obscure at best. When top nanagement looks for a realistic promise of profit, or asks for evidence that the roposals presented for review represent the best available computer opportunities, it typically finds that no good answers are available.

Top management has a right—indeed a responsibility—to raise hard questions bout any computer development proposal. The issue such questions address is asically that of *feasibility*—a concept often misunderstood and misapplied, but rucial to soundly based computer development efforts.

THE THREE TESTS OF FEASIBILITY

Recently the president of a German chemical company turned down a proposal or a management information system that would have provided him with a lesk-side cathode-ray tube inquiry terminal capable of displaying on demand ust about any kind of operating data he might care to request. He explained his lecision very simply: "I care more about what will happen five years from now han what happened yesterday. And I already get all the routine data I can andle. What would I do with more?"

The incident is significant because it typifies a trend. Computer technology has nade great strides in just the past few years. Fewer and fewer applications are xcluded from consideration because of limits on computer file capacity, nternal speed, or input/output ability; more and more technically exciting rojects are being proposed for management approval. Yet technical virtuosity is no guarantee of problem-solving potential. And since technical feasibility is no onger an important stumbling block for the great majority of business applications, it no longer makes much sense to delegate to computer rofessionals the key decisions on how to use the computer, as many companies re still doing today.

The concept of feasibility really takes in three separate questions. There is the est of *technical feasibility:* "Is this application possible within the limits of vailable technology and our own resources?" There is the test of *economic easibility:* "Will this application return more dollar value in benefits than it will ost to develop?" And there is the test of *operational feasibility:* "If the system s successfully developed, will it be successfully used? Will managers adapt to the ystem, or will they resist or ignore it?"

Particularly on complex and ambitious computer development projects, these key questions can seldom be answered once and for all at the time the project is proposed. Continuous reassessment of the technical and economic risks and payoff probabilities may be vital to keeping such a project on the right track. But a careful initial assessment can go far to avert costly misapplication of scarce computer resources.

It is dangerously easy, however, to avoid confronting the full implications of feasibility until a project is well under way. Operational feasibility is far too often neglected until the new application is actually tried out in practice and perhaps found wanting—the costliest kind of feasibility test. And economic feasibility—the measure of how much expected dollar returns will exceed expected cost—is frequently assessed rather casually on grounds that the important benefits are intangible, and intangible benefits can't really be evaluated.

Actually, of course, the very difficulty of measuring intangible payoffs is the best argument for imposing on managers the discipline of explicit evaluation. Computer personnel can provide the needed input on costs, but benefits can be realistically assessed only by executives who fully understand the activities affected and the policies that govern them.

To achieve its economic potential, a computer project may also require substantial operational changes—changes in corporate policies, staff reorganization, construction of new facilities and phasing out of old. It will certainly require the support of operating managers and their staffs, and it may also depend on the cooperation of dealers, suppliers, and even customers. Corporate computer staffs cannot really judge the necessity of such changes, much less implement them. At most, they can advise the operating managers who must make the final assessment of operational feasibility.

PAST SUCCESSES AND PRESENT PROBLEMS

Ironically, the basic problems currently besetting the management of the computer effort stem from the successes of the past. In 30 of the 36 companies, conversions of routine administrative and accounting operations to computer systems are already complete or nearly so. Typically, some of the people who accomplished these conversions now constitute the nucleus of a corporate computer staff, often reporting directly to top management.

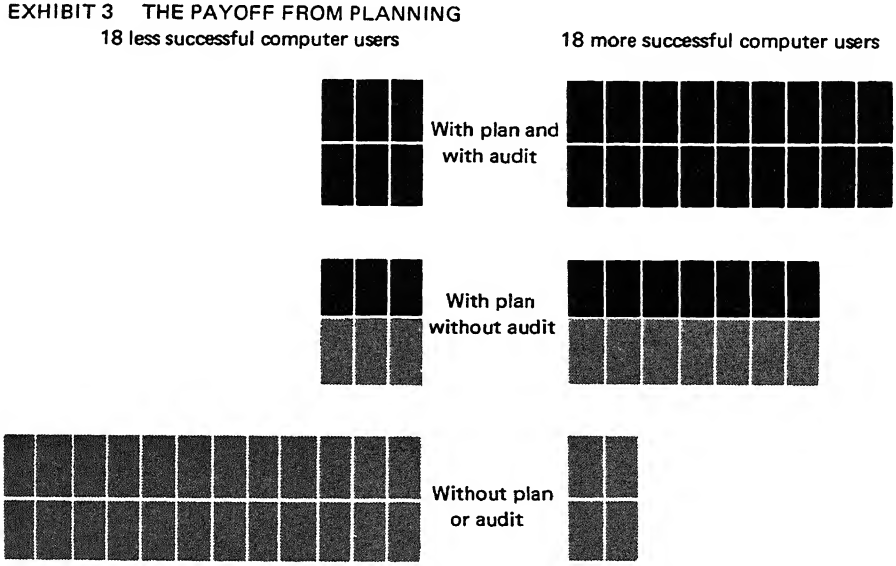
For obvious reasons, these computer staffs are under pressure to show results in the form of new computer systems. In terms of technical competence, they are well equipped to do so. But superb as their technical skills may be, they are seldom strategically placed (or managerially trained) to assess the economics of operations fully or to judge operational feasibility. Our findings indicate that these limitations are raising ever more serious obstacles to the success of new corporate computer efforts.

Another obstacle to future success, also stemming from past experience, is management's lack of exposure to the feasibility problem. Back in the days when corporate computer efforts centered on the conversion of accounting and administrative systems, management seldom had to concern itself with the issue of feasibility. With a relatively orderly manual system, the feasibility question centered on the technical problems of programming the computer. Economic feasibility was relatively easy to assess once a company had learned how to estimate conversion costs realistically, since the benefits could be measured in terms of clerical payroll reductions. And operational feasibility was assured when, as was usually the case, a single executive such as the controller had charge of both the development and operating phases of the new system.

Today the situation is very different. Applications are more complex and their impact on different operating departments is more far-reaching. The feasibility issue is bound up with complex economic and operational questions that the staff specialists are unequipped to answer. Yet far too many managers are still leaving the assessment of feasibility to the computer professionals, and neglecting their own responsibility for setting the direction of the computer development efforts. All this has two principal consequences:

First, current management practices and attitudes are falling short of the demands of today's task. Over the past five years, most computer staffs have doubled. Typically, the department that had 40 people in 1962 has 80 or 85 now, and expects to double again by 1975. Yet no overhaul of the management practices of earlier years has taken place. As Exhibit 3 indicates, 14 of the 36

EXHIBIT 3 THE PAYOFF FROM PLANNING



companies we studied still have no overall plan for computer applications and the economic and operational feasibility of individual projects is seldom fully explored. Twenty-four companies, including ten with a computer plan, have not established adequate short-term objectives against which to measure the progress of individual computer projects.

Second, the range of computer projects now open to many companies is circumscribed by the limited background of its computer personnel and the limited initiative of its managers. To make better use of computers in the future it will be necessary to expand the horizons of computer professionals and bring managers to a fuller awareness of the computer's vast potential.

THE OPPORTUNITIES: NEAR AND FAR-OUT

The computer's credentials as a cutter of clerical payrolls are now beyond dispute, and there is convincing evidence that it can make an equal or greater contribution to corporate profits by reducing the cost of goods sold.

The more successful companies in our study have recognized this potential and are already beginning to exploit it. The dominant lesson of their experience so far is that this second stage of the computer revolution, unlike the first, entails real operational changes—new and perhaps uncomfortable ways of doing business that may well be resisted at the outset.

For companies moving into operating system applications, moreover, the feasibility problem becomes more complex. Technical feasibility may again become an issue because marketing, production, and distribution systems are subject to outside influence and therefore less orderly than accounting systems. Economic feasibility becomes harder to determine since the benefits no longer derive from payroll reductions. Most significant, operational feasibility now stands or falls on the attitude of operating managers.

Teamwork, then, is the key. Even a fairly commonplace computer application such as inventory control requires it. Design engineers must give adequate notice of design changes; sales planners must furnish detailed product sales forecasts; and management must give guidance on spares requirements and desired customer service levels. Once established, such cooperation between managers and professional computer staffs becomes a real stimulus to profitable further applications.

Consider the case of a manufacturer of heavy construction equipment, whose first computer-based inventory control system went into operation well over a decade ago. In this company the computer now plays an integral and indispensable role in production planning and control. These are some of its tasks:

1 *Consolidating sales forecasts from 31 countries.* Forecast data are consolidated by region, product, and model, then correlated with historical data

to establish trends for each product group. The president and the vice president for sales use these staff analyses in their annual budget discussions with division heads.

2 *Establishing a quarterly manufacturing plan for each of 13 plants.* These plans are updated monthly by reconciling revised sales forecasts with records of finished goods inventory and products in final assembly. The revised manufacturing program is then exploded into component requirements, and a "net component requirement" analysis is prepared. With the help of some supplementary manual analysis, lead time between customer order and delivery has been sharply cut and costly reshuffling of finished goods among distribution depots has been reduced drastically.

3 *Maintaining cost schedules in all plants showing the economics of make-or-buy decisions.* In conjunction with the "net component requirement" report, these cost schedules make possible intelligent work-load leveling, better allocation among plants, and improved make-or-buy decisions.

4 *Central recording of all engineering changes.* With changes occurring at a rate of about 2,000 a month, the cost of writing off obsolete stock used to run as high as $1.5 million annually. The new system, which allows components in stock to be exhausted before a change is put into effect, has reduced this bill by two-thirds.

5 *Maintaining cumulative records on labor efficiency.* Besides providing detailed information on direct labor costs and trends, this system analyzes the work content of each component by work center—an invaluable aid to production planners.

The complex network of systems which produces such results has been evolving for 12 years now. Overall, management credits computers with reducing lead time between order receipt and delivery by three to five months for domestic customers, and with cutting direct labor requirements by 2 percent through improved materials availability and better control of work flow. Since direct labor costs are approximately $100 million per year, this fractional saving is significant both in absolute terms ($2 million) and as a percentage of before-tax profits (5 percent).

Another example of evolutionary development is offered by a major consumer goods corporation. This company gives its product managers and marketing staffs access to a comprehensive, detailed sales history file, in which total U.S. sales over three years are cross-referenced to show product sales data by geographic region, type of outlet, timing with relation to promotions, and packaging. This system, which evolved from a fairly elementary order entry and billing system, is being used today to schedule production at nine plants and to coordinate shipments from 13 warehouses. One gauge of its usefulness is the willingness of marketing managers to pay the salaries of the programmers who prepare on demand whatever analyses they may need.

Evolutionary development is typical of systems requiring audited data bases,

since these cannot be built up overnight. But other systems, equally ambitious, can sometimes be developed quite rapidly where management recognizes that the data-base approach is not the only, nor necessarily the best, way to develop advanced computer applications.

A manufacturer of high-style clothing, with national outlets and multiple plants, decided two years ago its computers (hitherto used only for accounting purposes) could help to forecast sales and to establish preliminary cutting schedules at the beginning of each season. The computer forecasting model it adopted has already proved so successful in matching production to demand that the company now plans to put computer forecasting to work in planning purchasing decisions.

Similarly, a number of oil companies have moved quickly into new fields unrelated to previous computer development work. In a matter of months, one company moved to transfer the production and maintenance records of thousands of domestic oil wells to computer files where they can be correlated and analyzed. This system enables production decline curves of wells and fields to be plotted and future production forecast under various alternative secondary recovery programs. It also calls management's attention to wells that are no longer producing enough to cover marginal costs.

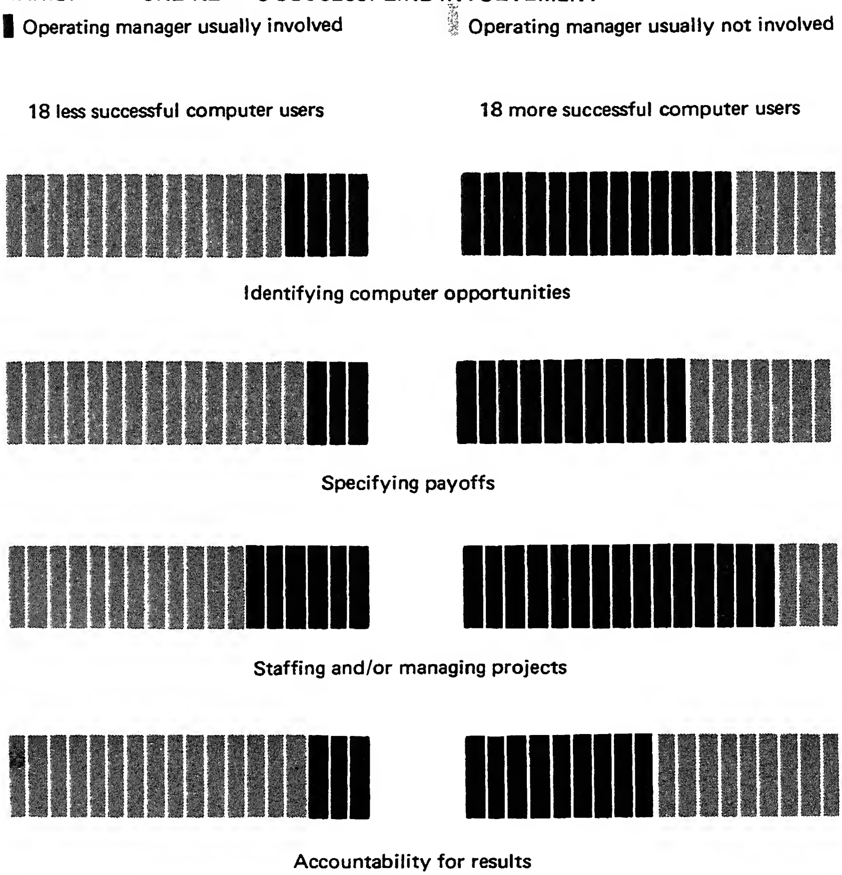
The principal task in developing this computer system was one of data reduction and file design, and here there was ideal matching of the talents of the computer systems men and petroleum engineers. With the engineers' enthusiastic support, the computer staff is now exploring the feasibility of making the same data accessible, through graphic display units, to its engineers in the field, who control expenditures in the hundreds of millions of dollars per year.

Finally, in industry after industry, the science of communications is being wedded to the science of computing to centralize record keeping, planning, and control in an ever-more-complex economic environment. Railroads have "control centers" where up-to-the-minute central records are maintained on the movement of freight and rolling stock. Retail chains are using teleprinters and central computer-based dispatch systems to reduce branch-store inventories by cutting the stock-replenishment cycle. A wood-products company is coordinating production at its nine mills to match sales orders transmitted by branch offices throughout the United States directly to a central computer. Banks are handling branch accounting centrally. And virtually all the major airlines now have their own versions of the seat reservation system that first proved computers able to control large communications networks on a commercially feasible basis.

It is often extremely difficult to assess the overall economic effects of these advanced computer applications, simply because no one can say where the corporation would be today *without* its computers. But it would be hard to convince many of these companies that the computer has nothing to do with the edge they have gained on the competition.

The resources—computers, professional computer systems men and programmers, management scientists, and communications experts—are available to all. But something more is required. Advanced computer application concepts with potential impact on the central activities of a corporation, must have sponsors high in the management pyramid to plead their case. It takes enthusiastic top-management leadership to gain the commitment of operating men—and it takes teamwork between operating men and computer professionals to turn imaginative concepts into practical reality. Indeed, as Exhibit 4 indicates, knowledgeable and well-motivated operating managers are likely to be a better source of ideas for profitable changes in operations than are computer professionals. The most profitable applications uncovered in our study had originated with operating executives pondering such ideas as these:

EXHIBIT 4 ONE KEY TO SUCCESS: LINE INVOLVEMENT



If only we had a way to test the reliability of the sales forecasts made by these regional managers of ours, we might not find ourselves out of manufacturing capacity in Italy at the same time that we're laying off valuable skilled labor in Brazil.

If only we had a way of recording and analyzing all our customer orders in one place, we ought to be able to allocate our production better—improve mill efficiencies and raise the yield from our raw materials.

If only we could easily check out our historical sales performance by product, package, and so on, maybe we could interpret our test marketing results faster and more reliably.

If only we could play with alternatives on our tanker deployment, we might use our capacity better—charter in less and charter out more.

If only we could project our needs for skilled labor three months out, we could save the expense of these crash recruiting and training programs.

For every company, our study suggests, there is a unique set of *feasible and profitable* computer applications—and most of these applications are closely related to the key strategic opportunities that the top executives are really concerned about: marketing and distribution operations in the package goods company, production operations in the capital equipment concern, facilities planning operations for the chemicals maker, exploration and producing operations in the petroleum company, financial planning in the conglomerate, and so on. And since each corporation has it own unique pattern of problems and opportunities, the computer development strategy that has worked well for one company may not work at all for its competitor.

In almost every industry, at least one company can now be found that is pioneering in profitable new uses of computers. In such companies, our findings suggest, the key to success has been a strong thrust of constructive interest from corporate operating executives who have put their own staffs to work on computer development projects. It may soon be a nearly universal practice to transfer operating staff to computer development projects, either by making them members of a project team or by attaching them for a year or two to the corporate computer staff.

In management information and control, another much-discussed area of computer use, a few companies have already succeeded in notably improving the quality and quantity of specific information available to operating managers. Others, as noted earlier, have made profitable use of the computer in decision making through simulation models. A well-known food products company, for example, has constructed and used a computer-based simulation model to assess, under various possible 1970 and 1975 environments: (1) the relative profitability of different product markets; (2) the desirability of investing in new-market development; (3) the impact of investment in added plant capacity; and (4) detailed income statements based on these projections.

Again, computer-based risk analysis techniques have demonstrated their value

in a wide range of capital investment situations. The industrial chemicals industry is known for the magnitude of both its investment and its risks. Risk analysis, made practical by computers, has proven invaluable for evaluating alternative strategic plans with the help of simulation models, sometimes even including simulation of alternative competitive responses by the application of game theory. To exploit the potential of these and related techniques, an increasing number of corporations are finding it necessary to supplement the professional skills of computer men by recruiting specialists in the management sciences.

In recent years, too, much effort and ingenuity have been devoted to the design and promotion of so-called total management information systems. Many businessmen are understandably intrigued by the possibilities of such systems, but they are as yet a long way from practical realization in business.

Doubtless the computer's information processing capabilities will one day eliminate the need for large staffs occupied with collecting and interpreting information from various sources for the use of decision makers. But whether the computer will ever be able to evaluate strategic opportunities or indicate the proper timing for corporate actions is by no means assured. Nor are man-machine dialogs via desk-side consoles likely to become a feature of life in the executive suite any time in the foreseeable future. Top management's principal "interface" with the computer is likely to remain the old-fashioned telephone, with a human information specialist at the other end of the line. What really counts is not the gadgetry but the responsiveness of computer-based systems to management's information needs.

Research on comprehensive computer-based information systems, then, may be a sound investment for some companies, even though the costs of experimentation are high. But no company should embark on a program to develop a major management information system except to meet a specific, well-defined need. Even then it should carefully weigh its options—including the option of applying its scarce computer resources to areas where operating success and economic payoff can be predicted with greater confidence.

KEYS TO THE FUTURE

In embarking on the present study, we were concerned with measuring the gap between potential and performance, analyzing its background and causes, and synthesizing from the practices of the top performers a few succinct management guidelines for maximizing the computer's effectiveness and unlocking its profit potential.

In the computer field, as in other areas of management, the usefulness of generalizations from successful experience is rather sharply limited. It is possible to state *some* of the principles a company must follow to have a reasonable

chance of success with the computer. But there will always be certain constraints, needs, and opportunities that are peculiar to each company and can only be weighed in the light of the individual situation. Hence it is useful to state general precepts only if their neglect is rather widespread and the consequences of that neglect are costly. That, unfortunately, is the case with most corporate computer efforts today.

The common denominators of successful computer practice, as seen in the companies we have examined, can be boiled down to three principles: the rule of high expectations, the rule of diversified staffing, and the rule of top-management involvement.

THE RULE OF HIGH EXPECTATIONS In all of the companies that are realizing outstanding *economic* results from computer applications, top management is simply unwilling to settle for anything less. Departmental and divisional managers in these companies know that top management will insist on economic results—and that they will be held personally responsible for achieving those results.

The new president of a capital equipment manufacturer, who has succeeded in getting a badly stalled computer program in his company moving again, typifies the prevailing tone of management expectations in the better-performing companies. Said he: "I ask my department heads to give me regular formal reports on their current successes and failures with computers and their future objectives. Right now they're a bunch of sheep with computers. I aim to convert them into enthusiasts, so that later I can be jockey, not herdsman."

THE RULE OF DIVERSIFIED STAFFING Recognizing that computer professionals alone seldom constitute an adequate corporate support staff, the top-performing companies take either of two organizational approaches. Some assign to the corporate computer staff—along with the usual operations research specialists and other professionals—at least one talented individual with experience in each of the major functions of the business. Others, relying on the project approach to computer development, use project teams staffed by temporary transfers from operating departments.

To head up the computer staff and assume responsibility for the implementation of development plans, each of the outstanding companies has taken care to pick a manager who can command respect and confidence throughout the organization. Their experience indicates that this man's effectiveness depends more on his personal stature and professional skills than on the location of his unit in the corporate hierarchy. We found no evidence, statistical or otherwise, to suggest that high organizational status assures effective performance on the part of the corporate computer staff.

THE RULE OF TOP-MANAGEMENT INVOLVEMENT If any one man can be said to hold the key to the computer's profit potential, it is probably the chief

executive. There are five responsibilities that he really cannot delegate if he wants to get maximum results from his company's computer effort:

1 He must approve objectives, criteria, and priorities for the corporate computer effort, with special attention to the development program.
2 He must decide on the organizational arrangements to carry out these policies and achieve these objectives.
3 He must assign responsibility for results to the line and functional executives served by the computer systems—and see to it that they exercise this responsibility.
4 He must insist that detailed and thorough computer systems plans are made an integral part of operating plans and budgets.
5 He must follow through to see that planned results are achieved.

There is nothing novel in any of these recommendations; they are standard operating practice for the chief executive in most of his traditional areas of responsibility. Many otherwise effective top managements, however, are in trouble with their computer efforts because they have abdicated these responsibilities to technicians who have neither the operational experience to know the jobs that need doing nor the authority to get them done right.

Only managers can manage the computer in the best interests of the business. The companies that take this lesson to heart today will be the computer profit leaders of tomorrow.

READING 11 DISCUSSION QUESTIONS

1 "The computer has had little impact on most companies' key operating and management problems, where its real potential lies." Discuss this statement.
2 How are the costs which go to make up computer expenditures distributed?
3 What may be the consequences when executives neglect their own responsibility for setting the direction of the computer development efforts?
4 There were three principles of successful computer practice gleaned from the McKinsey study. Identify and discuss these "keys to the future."

READING 12 A MESS IN MIS?*

ARLENE HERSHMAN

"Wanted—corporate director, management information systems, report to the president. The man for this key position in a planned expansion of better information systems is probably earning at least $25,000 annually."

*Reprinted from *Dun's Review*, pp. 26-27ff., January, 1968. Reprinted by permission from *Dun's Review*, New York. Miss Hershman is a staff writer with *Dun's Review*.

This recent ad, placed by a \$400-million-sales multiplant manufacturer, is by no means unique. Not a day goes by without such job offers, all of them at salaries of \$20,000 or more and most of them dangling such added inducements as a direct line to top management and the last word in computer hardware with which to work. The director of management information systems has become one of the most sought-after men in the corporation today.

What this phenomenon points up, of course, is top management's growing reliance on the computer to help in decision-making and its willingness to invest millions of dollars in equipment and manpower to put together a management information system. What management ultimately expects is a total system that will instantaneously provide all managers—at every level from plant foreman to chairman of the board—with every fact they need to know in order to make a decision.

But is this possible? And do the results of MIS justify all the money and time that have been poured into it? Probably not. Despite some reported successes, management's headlong commitment to MIS does not seem to have been worth the effort—at least so far.

Indeed, to many line executives who are faced with tough decision-making problems, MIS seems to be creating more problems than it solves. As A. R. Zipf, executive vice president of Bank of America recently told a seminar at Harvard: "We have seen over the past twelve years some incredible blunders. Twinkling lights, spinning tapes and pastel cabinets seem to have a mesmerizing effect on some managers. In a pell-mell rush to be among the first to play with a new toy, enormous sums have been wasted."

Typical of the complaints from managers who are supposed to be reaping the benefits from MIS is this one from an executive of the Norge division of Borg Warner: "In computerized sales forecasting," he says, "the computer is supposed to be able to project forward what has happened before to help the company decide which products within a line it will produce."

"But," he adds, "a forecast based on computers—at least at our degree of sophistication—isn't very helpful. Unfortunately, there is no way to design a computer than can call the turn. As long as sales are going up, it says so; as long as sales are going down, it says so. But to get over the hump either way becomes an intuitive problem. The sales forecast may be a help for long-range planning, but for the first quarter of next year it leaves a lot to be desired."

Other companies have made the same discovery. Radio Corp. of America, with the latest in sophisticated equipment at its disposal, has found that sales forecasting will not reveal any brief downturn ahead in sales of color-TV sets. Likewise, brokers and investors have been forced to the realization that "forecasting by computer" does not mean a thing in the day-to-day area of buy or sell decisions.

The high price of computer knowledge and overzealous sales techniques by the hardware manufacturers have brought about disappointment to many companies. Explains Bank of America's Zipf: "All too often, computer systems were

installed without even rudimentary thought about their cost, their efficiency and, most important, their applicability to the job that needed to be done. One cannot begin to estimate what computer hysteria cost the banking industry. I doubt that anyone will question that the costs were measured in the tens of millions of dollars."

It is hard to calculate what the total bill for MIS now runs to. Most companies do not break down costs between the computer that is doing a job and one that is merely producing information. But of the total $10 billion invested in computerization by U.S. industry, perhaps 10% is being spent for MIS projects alone.

"Every baby is born ugly," says the old Spanish proverb. But even after allowance has been made for the shortcomings of infancy, responsible critics point out, MIS has failed in its principal purpose: to produce the information that management needs to run the business. Here, the record of MIS mismanagement is writ large.

A major cause of frustration is the uselessness of much computerized information. Overdetailed reports are spewed forth by 600-line-a-minute printout machines, inundating management with all the information it does *not* need to make a decision. First National City Bank of New York, for example, can point with pride to the many real achievements of its EDP operation in creating new revenues, attracting new customers and improving budgeting. But in the area of MIS, the record is something else again. Vice President Robert Owen, who was recently assigned to whip the bank's MIS program into shape, pinpoints the trouble: "The chief executive knows that the problems of the business are hidden somewhere in that pile of print, but he cannot find them."

Even success in applying the computer to one company problem offers no assurance that all MIS applications will respond equally well. The Columbia Broadcasting System has had remarkable results from its FREEDA system for keeping track of sales of available air time; the system was able to unify the record-keeping problems of four separate departments, eliminating all duplicate records, and provide instant information on the status of time sales as well.

However, the head of another CBS department complains: "Before the company started computerizing my department, it took me a month to get a progress report, which was too long a time for it to do me any good in catching trouble spots. Now I get a report every other day—but it takes me two months to read it."

While attempts to bridle the monster MIS have so far been mostly unsuccessful, many companies have at least been forthright in owning up to the situation. By now the records of their defeats has gone beyond the finger-pointing stage to the need for a careful study of just what is hobbling the progress of MIS and what can be done about it.

First of all, the term itself needs to be defined. "Nobody knows what a management information system is," compalins a spokesman for Union Carbide

Corp. Adds First National City's Robert Owen: "If we had fifteen experts in this room, we would have fifteen definitions. We are working in an area where we have no firm foundation tracked back into a discipline, such as cost accounting for instance, that has been developed over the years."

Then there is the question of objectives. Just what the ideal management information system should be is the subject of hot debate between management personnel and EDP experts. Many machine men envision the ultimate in decision-making environments for MIS. They conjure up visions of the company chief executive sitting in his oak-paneled office asking the most complex and esoteric questions of his own private crystal ball: the cathode-ray-tube console.

MUCH MORE THAN HARDWARE

But all the talk about hardware overlooks the most vital fact: a management information system involves much more than just computers and equipment. "Somehow," declares Bank of America's Zipf, "it has escaped some people that an effective management information system must start with an understanding of management rather than with a survey of computers and display devices."

In other words, much of the failure in MIS can be laid directly at the door of management. Computer experts particularly blame managers' lack of involvement in the design of the system. In fact, they say, managers very often do not even know what information they need to make a decision. "You just can't put in a system," declares Richard A. Gilbert, administration vice president of Mead Corp., "without the cooperation of the management personnel who are using the information."

To a great extent, then, the lack of progress in MIS has been caused by antagonism between line and staff men. Managers blame the systems experts for not giving them the information they need. The computer men, on the other hand, blame the managers for not knowing what information they want. What this conflict points up, of course, is that MIS can strike at the very heart of corporate life: no manager wants to lose his influence and power to a computer. Thus the battle lines are drawn, and the most likely result is an overflow of useless information.

More than that, it can mean a tremendous waste of money. And with the millions of dollars that a company must invest in a management information system, one of its major concerns is naturally profitability.

But can a company determine that profits will be better as a result of MIS? The answer seems to be that it cannot. All of management's feasibility studies to prove potential profits, say the skeptics, only prove how badly it wants to use MIS.

In the face of this difficulty, a number of companies have come up with alternative methods of evaluating MIS proposals. Procter & Gamble, for

example, requires each branch manager to pay out of his own budget the costs of research and development, programming and overhead for any new project. Since in the P&G organizational setup this means the allocation will be reflected in the manager's yearly bonus, a very real check has been imposed on managerial overenthusiasm for information. Other companies, Weyerhaeuser for one, have set up priority programs to guard against misuse of MIS.

In totting up the MIS track record, the most successful systems seem to be those that begin small and progress in stages. At this point, management is incapable of handling large and elaborate MIS programs; thus companies are cautiously setting up limited programs as the starting point for more sophisticated systems in the future.

Procter & Gamble decided as long ago as 1957 against an all-out MIS program. As a company spokesman admits: "We didn't know how to design and install any kind of a workable 'total system,' and it was too big and too tough a bite—certain to produce indigestion." Instead, P&G chose to build up a series of subsystems that could ultimately tie into a total system.

RCA initiated a very slow pay-as-you-go program in 1966, budgeted at $30 million a year. Based on a five-year plan, it calls for a gradual building up of subsystems. Most important, it also calls for a hammering out of objectives between the line men who will use the information and the staff men who will implement the schedule. Sums up RCA systems man Bruce Curry: "We are proceeding with deliberate haste."

But building up subsystems, while seemingly the most popular method, is fraught with the same perils as any other approach to MIS. It can only be successful when the parts are compatible with the whole and produce an easily integrated system. Integrating the subsystems is a large job in itself.

Even the Department of Defense, admits Assistant Secretary Robert Anthony, is a long way from combining the various pieces of its system into an integrated whole. With a budget that runs to $40 million annually, says Anthony, even the most obvious application, an integrated payroll system, is still two years away "despite the fact that intensive, high-quality preparation has been going on for at least two years."

Adding to the burden of integration, most companies are loaded down with a multitude of incompatible subsystem units. Union Carbide, for one, has spent two years trying to meld its half-dozen different computer systems, and the end is nowhere in sight. Says one staff man: "We have islands of automation that can't be connected until we get the commonality. When all the divisions have gone to third-generation equipment, we expect to have more chance of success."

Clearly, MIS so far has been plagued by confusion and missteps. This has naturally led to disenchantment on the part of management and a very real fear of throwing good money after bad.

In the opinion of the experts, however, MIS can work. What is needed above all else, they insist, is a true understanding by top management of what MIS

really is and what it can do. Sums up Bank of America's Zipf: "I am hopeful that if business generally will face up to the facts and use computer technology to meet needs rather than to employ hardware, to produce profits rather than status, to evolve meaningful and economically sound information systems rather than glamorous and wasteful projects, the day of fully integrated MIS may dawn with man still in command."

READING 12 DISCUSSION QUESTIONS

1 "There is no way to design a computer that can call the turn." Discuss this statement.
2 "Much of the failure of MIS can be laid directly to the door of management."
   (a) Is this a true statement?
   (b) Does it differ from statements made in the preceding reading?
3 What can be done to reduce the probability of failure in MIS?

READING 13 TRENDS IN THE USE OF DATA SYSTEMS*

RICHARD G. CANNING

With the bulk of the conversions of recordkeeping operations to EDP behind them, many data processing staffs are beginning to shift their attention to functions that will directly assist in the management of their companies. These functions include aid in the selection of courses of action, and in the checking on compliance.

Four major uses are beginning to develop along this line: (*a*) assistance in corporate planning, (*b*) fast, flexible reporting, (*c*) system integration through a corporate data file, and (*d*) use of a fast response system.

COMPUTER-ASSISTED CORPORATE PLANNING

The pattern for this use of the computer has been set by the Department of Defense's planning-programming-budgeting system. The DoD system has been successful in tying plans to long range goals, and budgets to plans. Interest in the

*Reprinted from *EDP Analyzer*, vol. 4, no. 8, pp. 8-11, August, 1966. Reprinted by permission from Canning Publications, Inc., Vista, Calif. Mr. Canning is the author of several books in data processing, is a consultant, and is the publisher of *EDP Analyzer*.

system is growing, as illustrated in an article by Smalter and Ruggles in the March-April 1966 issue of *Harvard Business Review* ("Six Business Lessons from The Pentagon").

The approach consists of developing data files that represent the status of both internal and external conditions and then periodically analyzing these files for opportunities, challenges, problems, etc. For example, a firm might find from analyzing their customer file that certain customers are beginning to reduce their volume of purchases for some product lines. Further analysis might uncover the fact that these customers are all located in one geographic region. An analysis of a data file describing something about the markets and the competition might point to the action by one competitor in that region as the probable cause. When such a trend has developed sufficiently it usually is obvious without the need for a computer analysis. The benefit of the computer is that it can give a warning signal earlier, and under conditions of many products, markets, and competitors.

Once a list of challenges, opportunities and problems has been developed and ranked in importance according to corporate goals, the next step is to evaluate possible solutions for each. One approach to this evaluation is to create a model of each solution considered and then test each model's performance on the computer under different assumptions about future business conditions. The model might be primarily mathematical in form (such as a linear programming model) or logical in form (such as a simulation model). The results of the evaluation hopefully will give some insight into the effectiveness of the alternative solutions.

(The creation and validation of a model is often an expensive, time consuming affair. For example, one moderate size model that was described to us recently required the part-time services of three computer professionals for over eight months, amounting to the better part of two man-years of effort. Techniques are being developed to reduce this model-building time, as we will discuss later in this series of reports, but to date the techniques have not been applied widely. With the present state of the art, models most likely will be created only for the more risky, larger investment type of opportunities and challenges.)

Once a solution has been chosen for one of the opportunities or challenges, the next step is to implement that solution by means of a project. Again, the computer can be of assistance—by helping to create a PERT-type network for the project, computing the critical path, aiding in revising the network if the elapsed time is too long, and computing the new critical path when actual progress differs from planned progress.

Under the present state of the art, all of these steps for aiding in corporate planning are well developed. The over-all technique is possibly still too expensive for all save the largest corporations—although smaller businesses can use portions of the technique profitably. But as more experience is gained, it is likely that general purpose techniques will be developed, so as to bring the costs down. We expect to see significant progress in the use of computers to aid corporate planning, in the next five years.

FAST, FLEXIBLE REPORTING

Briefly, we see the reporting system as consisting of three main components: overall performance reports, triggered (exception) reports, and special analyses performed on demand. The performance reports may be developed on a scheduled basis (weekly, monthly) or may be produced on demand and would be comparable to today's summaries of operations. The main difference would be that, if an unsatisfactory condition were detected, a manager could probe for the cause of that condition. That is, he could ask the computer to display the lower and lower levels of detailed data that applied to the unsatisfactory condition. With today's reports, a manager can probe only a short distance before the reports can do him no further good. With the computer he should be able to continue his probing to the lowest level of detail, should that be necessary.

Triggered reports would be those reports that call for some type of human action—something is "out of control." Again, the manager can probe for the causes behind the condition by looking at successive levels of detail data. Note that this probing action is highly selective; the manager sees just the data he asks for, he does not have to look at volumes of inappropriate data.

We heard a good criticism lately of the "management by exception" principle, based on the experience of one company. If the only reports that an executive sees are exception reports, indicating out-of-control situations, he may be inclined to overcorrect. He should see these exception reports in the perspective of overall performance. At this one company, the president issued memorandums for many of the exception reports that he received— memorandums that tended to conflict with instructions already issued by lower level executives. His vice presidents finally prevailed on him to give up the exception reports and go back to the regularly scheduled performance reports. It is reported that things have run more smoothly since this occurred.

The argument here, in our opinion, is not so much against exception reports as it is against exception reports *only*. We see the exception report, triggered by some noteworthy situation, as being an integral part of the management reporting system.

Special analyses produced on demand would just be another example of the ability of a manager to probe the data files. We mentioned the need to probe files of both internal and external data, for uncovering opportunities and challenges; this will be one use of these demand reports. Also, a manager might want to go back into historical data to detect the beginnings of an unsatisfactory trend. Or he may want to correlate data that is not regularly correlated in the scheduled reports.

During the next five years, the first developments along this line that will be installed will most likely be simple inquiry systems. We have seen several such systems in operation already—for instance, for reporting the location of shop orders in an aerospace production control system. Such systems will usually be used by the operating levels of management rather than by higher level

executives. In some companies, special files will be created to support a management information system, allowing managers to probe and ask for demand reports as discussed above, to a limited extent.

But it may be after 1971, for most organizations, before the demand probing concept can be applied widely to regular data files. The reason for the delay is just the magnitude of the task of structuring the "corporate data file."

THE CORPORATE DATA FILE

Even though many companies now have massive data files on magnetic tape, these files are often not too useful for management purposes. Definitions of data fields often vary between different data files, or between the same file at different geographical locations. Data formats may not be compatible between the different files. If different computers are used, it is possible that different data codes are used and with no convenient way to convert to a common code so that magnetic tapes can be exchanged. Special programs may be needed to retrieve desired data from different files and put it in a form that can be compared. Under such circumstances, it can take weeks or even months to perform a special data analysis requested by management.

Interest is growing in the concept of a centrally controlled set of data definitions and formats, so that all "public" data files within the company are consistent. By "public," we mean files that serve multiple users, as most data files do; security restrictions may apply to some of the files, or to some fields within a file, such as the salary field within a personnel file. With a consistent set of data definitions and formats, the problem of retrieving and correlating data would be greatly simplified.

It is this concept of centrally-controlled data definitions and formats that we are calling the *corporate data file*. The data itself may be filed at diverse geographic locations, as long as common definitions and formats are used.

The corporate data file will contain types of data in addition to those now stored in the magnetic tape files. There will be a growing desire to store more detailed historical data, particularly since the cost of storage and processing are coming down rapidly. Planning data will be an important element in the files when computers are used to assist in corporate planning. Business intelligence data will be obtained and stored in a more systematic manner.

In addition to storing more data in its own files, a company will find it desirable to purchase data in machine language form from outside sources. A market is now developing for two main types of data—financial data about corporations, and market data—and the purchase of such data may become commonplace. In addition, other types of data are being offered for sale, such as legal precedent data. Purchased data may become as much a part of the corporate data file as the company's own files.

In addition to these new types of data, the corporate data file will require a central data catalog, which gives the definition of each data filed within the system as well as the file(s) in which it is located.

The building of the corporate data file will be a very large undertaking. Obtaining agreement on a set of common data definitions and formats will be a big job in itself. The design of the files, for efficient storage and retrieval, will tax our current knowledge of optimum file organization.

In the next five years, we would expect that much of the effort will be expended in building the corporate data file, but with only limited use of it for management purposes. It looks to us as though it will be after 1971 before many companies are in a position to provide the type of probing discussed above, in connection with a management reporting system, simply because of the magnitude of the job.

FAST RESPONSE SYSTEMS

There is growing interest in the selective use of fast response systems and we expect this trend to continue. Perhaps the most active area of application currently is in those situations where "the customer is waiting" and it is desired to give faster, broader, more accurate service. Airline reservation systems, savings bank systems, the Westinghouse order entry system, and stock price quotation services are examples. Other applications include machine assistance for handling operating functions—such as the use of time-shared systems to aid in program creation and debugging, or the use of on-line keypunching.

Real-time systems are one form of fast response systems. While the definition of real-time may be open to discussion (if paychecks are desired weekly, and a system produces them weekly, is it a real-time system?), the general consensus is that a real-time system must meet a rather severe time constraint in its processing. An airline reservation system must be able to handle peak loads of inquiries, sales, and cancellations without any customer having to wait "too long" for service—perhaps in the order of a minute or so. If a system component fails, the system still must operate although service times may increase.

Time-shared systems appear to be similar to real-time systems but differ in several respects. Time-shared systems are aimed at providing service to many remote users, hopefully in a manner that each user thinks that he alone is using the computer. But, in fact, users know that they are sharing the computer and they become accustomed to waiting for service when there are many users on the computer. Thus, a time-shared system does not operate in as severe a time constraint environment as does a real-time system.

We expect to see growing interest in both real-time and time-shared systems in the next five years. But we think that the use of these fast response systems will be selective, and not applied to all data processing. In fact, the bulk of the data

processing will continue to be performed in a batch mode of operation. The question then arises as to how the batch processing might best be handled, if a fast response system also is in operation. Will the batch processing be run on separate computers dedicated to the batch jobs? Or will the batch jobs be run as "background" on the fast response system—that is, worked on by the computer when it is not performing some more urgent task? Or will the batch jobs be run on the second and third shift, when the fast response system may not be in operation? It is not clear yet just which of these solutions will be most widely accepted.

In the next five years, we would expect to witness the arrival of on-line key punching and the initial uses of display consoles. Some management reporting systems, using special files, will be installed; the teletypewriter will be the most commonly used terminal for this service during this time period. And the field will see the arrival of the first computing utilities aimed at business services, such as the Keydata Corporation in Cambridge, Mass.

Beyond 1971, the use of fast response systems will continue to grow, with much of the growth due to the wider acceptance of the computing utilities. Even where companies continue to use their own computers, rather than buying computing services from a utility, the trend appears to be toward centralization of computers. For central computers to provide satisfactory services to remote locations, some fast response will be needed. This growth in fast response systems appears to be an important trend in the field.

READING 13 DISCUSSION QUESTIONS

1 How can a computer assist managers in
  (a) planning?
  (b) controlling?
2 (a) What are triggered reports?
  (b) What is the difference between a performance report and a triggered report?
3 What criticism might be aimed at the "management by exception" principle?
4 Why will the building of a corporate data file be a very large undertaking?

READING 14 WHAT THE COMPUTERS WILL BE TELLING YOU*

PETER F. DRUCKER

There are still a good many businessmen around who have little use for, and less

*Reprinted from *Nation's Business*, vol. 54, no. 8, pp. 84-90, August, 1966. Reprinted by permission of the publisher and the author. © 1966, *Nation's Business*—the Chamber of Commerce of the United States. Mr. Drucker is a management consultant, educator, and writer living in Montclair, N.J.

interest in, the computer. There are also still quite a few who believe that the computer somehow, someday will replace man or become his master.

Others, however, realize by now that the computer, while powerful, is only a tool and is neither going to replace man nor control him. Being a tool, it has limitations as well as capabilities.

The trick lies in knowing both what it can do and what it cannot do. Without such knowledge, the executive can find himself in real trouble in the computer age.

The computer is transforming the way businesses operate and is creating problems as well as opportunities. For example:

The mistakes you make are more likely to be whoppers.

You will have much more flexibility in how your business is set up.

You will need to have alternative courses of action planned in advance.

Eventually we will use computer centers as we now plug into public utilities.

We will be able to control manufacturing processes more through direct observation.

Someday we will have little need for computer programmers.

Mankind has developed two kinds of tools. Tools which do something man himself cannot do, such as the saw. The saw, the wheel, the airplane are all tools that add to man a new dimension of capability.

The other kind of tool is one that does much better what man can do himself. The hammer belongs here and the pliers. And so does the computer. These are the tools that multiply man's capacity. They do not enable him to do something he could not do before, but to do it better, faster and more reliably.

The computer is a logic machine. All it can do is add and subtract. This, however, it can do at very great speed. And since all operations of mathematics and logic are extensions of addition and subtraction, the computer can perform all mathematical and logical operations by just adding and subtracting very fast, very many times. And because it is inanimate, it does not get tired. It does not forget. It does not draw overtime. It can work 24 hours a day.

Finally, it can store information capable of being handled through addition and subtraction, theoretically without limits.

FIVE BASIC COMPUTER SKILLS

What then can the computer do, for the businessman? There are basically five major tasks it can perform.

1 The computer, as a mechanical clerk, can handle large masses of repetitive, but simple, paper work: Payroll, billing and so on. All this application really uses is the speed of the computer.

2 The computer can collect, process, store, analyze and present information at dazzling speeds.

So far, however, business has used only a small part of this capacity. We use the computer to collect, store and present data. Very little use is yet made of the computer's capacity to analyze information. The computer can, if properly instructed, compare the data it receives against the data it had been told to expect—for instance, budget figures. It can immediately spot any difference between the two sets of data and alert management. It can do even more than that. It can analyze data against an expected pattern, and detect any significant deviation.

One business application, for instance, is the analysis of sales data to pinpoint a meaningful and important market segment.

Do physicians in the suburbs use the same prescription drugs as physicians in small towns, or are suburban physicians a distinct market segment? And do medical specialists—the pediatricians, for example, as against the internists—prescribe differently? Are they a specific market segment?

Or what about old doctors versus young ones?

Somebody has to think up the questions. But once the computer has been instructed, it can almost immediately analyze actual prescriptions written by physicians and come up with the answers.

GET THE RIGHT FACTS

What this means is that managers must carefully think through what information it is they need.

The first step towards using the computer properly is to ask this question: How do we use it to make available the minimum of data, but the right data? What data is relevant for the sales manager, the factory superintendent, the salesmen, the research director, the cost accountant or top management?

The computer's capacity to provide people with information they need, in the form they need it and at the time they need it is the great versatility of the tool. So far it is not used too well by most businesses.

Most companies, in deciding on capital investment, still look at only one kind of analysis:

Expected return on the investment.

The number of years it is likely to take before the investment repays itself.

Or present value of the anticipated future earnings, the so-called discounted cash flow.

Accountants argue hotly about the advantages of each of these methods. Actually they are all valid and all needed. Hitherto, management had to be content with one because it was simply too much work to get all three. This is no longer true. Management can now ask to have capital investments calculated in all three ways by the computer—then look at all three and see which tells the most.

In other words, management has to make the information capacity of the computer fully productive.

3 The computer can also help design physical structures.

Program into the computer all the factors that go into building a highway, plus the basic features of the country across which it is to be built. The computer can then work out very rapidly where the highway should go to take full advantage of the physical and economic characteristics of the terrain.

Here the great capacity of the computer to handle large masses of variables quickly comes into play. Here also its ability to convert graphics into numbers and numbers into graphics is of great importance.

This ability to work out physical design will find its greatest application in the physical sciences where there are clear, known predictable occurrences—that is, natural events. Social events are at best probable, never certain. Therefore, this physical design capacity is a tool of engineering, of chemistry or physics, rather than of business.

4 The computer has the capacity to restore a process to preset conditions, to "control" a process, and this application is highly relevant to business operations.

For instance, if the computer has been programed for a desired level of inventory and for the factors that determine inventory levels (sales volume, volume of shipments, volume of stock, etc.), it can control inventory. It can tell you when your stock of certain items should be renewed. It can order goods to be assembled for shipping to a customer. It can even actuate machinery bins and put the goods together into one shipping order.

It can do the same for all processes for which we can set the desired level.

This is what people mean when they talk of the computer's making "operating decisions." But this is a gross misnomer. The computer does not make any decisions. It simply carries out orders. The decision has to be made first, and the computer told what to do.

BUT ONLY AN ORDER-TAKER

What the computer can do is serve as a monitor and immediately notice any change between the expected and actual course of events. It can then report what it has noticed.

We can go one step further and tell the computer how to react to a given event. The computer can then carry out our orders. It can shut down a machine or speed it up. It can close a valve or open it, thereby changing mixtures. It can print out a purchase order or a shipping order.

It can carry out whatever order we first put into it.

5 Finally, the computer can, and will, play an increasing role in strategic business decision-making—deciding what course of action to take. Here we no longer deal with restoring a process to a predetermined level. We are talking about decisions to change the process.

What the computer can do here is simulate. It can rapidly work out what would happen if certain things were done under certain assumed conditions. It cannot determine what things might be done. And it cannot determine the assumptions. Both have to be determined for it.

But it can tell you, for instance, that the introduction of a new product at a given price and given cost would be justified only if you could assume a certain volume of sales.

SETTING PRICES, PREDICTING MARKETS

It can tell you that a new product at a certain price and with a certain volume of sales would have to cost no more than a certain amount to be economical.

It can tell you what market you have to assume for a new product to have a chance of success.

It can also tell executives what assumptions management has made, consciously or subconsciously, when it reaches a decision. If we build a new plant with a certain capacity, for instance, how much must it be able to sell, for how long and at what price to earn a given return on the investment?

Simulation has largely been used for events which are predictable and occur regularly.

So far, no one has successfully simulated a major strategic business decision. Such a decision involves future social, political and economic events for which there are no known predictabilities and laws. Thus, strategic business decisions will remain risk-taking decisions. But the computer will soon be able to point out what we assume when we make this or that decision and what decision follows logically from this or that assumption. This applies particularly for recurrent business decisions, such as introduction of new products, pricing decisions and the simpler kinds of capital investment.

The use of the computer as a tool in strategic decision-making is perhaps our most exciting possibility. For it means that business managers will have to learn to think systematically about strategic decisions, and learn how to find and analyze alternatives of strategy.

WHAT THE COMPUTER CAN'T DIGEST

However, the computer can't handle all information. It can accept only information capable of being quantified and dealt with logically. This is only a part of the information necessary in the business world.

The information most important to a businessman is not capable of being quantified. It can only be perceived. This is information about something that is about to happen, information about a change in the trend.

This becomes particularly critical in events outside your business, events in the economy, the market, in society. Here what matters is the new, the unique, the event that signals a change.

The computer cannot bring outside events, by and large, to the attention of management. Therefore, management must realize this limitation of the computer. It is above all a tool for controlling events within the business.

However, it is only on the outside that a business has results. Inside a business there are only costs. Only a customer converts the efforts of a business into value, revenues and profits.

This all means, indeed, that the computer can become a terrific obstacle. If the tremendous amount of inside information the computer makes available causes management to neglect to look outside—or become contemptuous of the messy, imprecise, unreliable data outside—then management will end up on the scrap heap.

On the other hand, the computer can enable businessmen to devote a good deal more time to looking at the outside and studying it than they can now.

As a result of the computer, there will be fewer and fewer small decisions and fewer and fewer small mistakes. The computer will make small decisions into big decisions. And if they are made wrongly, the mistakes will be pretty big ones.

It is simply not true that the computer will eliminate middle managers. On the contrary, the computer will force middle management to learn to make decisions.

A regional sales manager today makes his inventory and shipping decisions on an *ad hoc* basis. They are not really decisions, but adaptations. But he also does not run much of a risk. Each decision stands by itself and usually can be easily reversed.

But to enable the computer to control inventory, a decision has to be made and the decision has to be thought through. It is neither easy nor riskless.

On the contrary, it implies very major decisions with impact on the entire business, including customer service, production schedules and money tied up in inventory. You have to think through whether you can afford to give all customers 24-hour service on all products. This usually means an absolutely impossible inventory and a totally chaotic production schedule.

If you can't afford that, do you give this kind of service only to good customers? And how do you define a good customer?

And do you give this service to all your products, or only to the major products.

And again, what is a major product?

These are not easy decisions. Until recently there was no need to tackle them. Each specific case was handled as a unique event. If a customer didn't like the way he was treated and squawked, one treated him differently the next time.

But as far as the computer is concerned, inventory and shipping instructions have to be based on a fundamental policy: They have to be decided on principle. And this goes for all other so-called operating decisions.

They all become true decisions. Otherwise, one cannot instruct the computer to execute them.

MAKING BETTER MIDDLE MANAGERS

The greatest weakness of business at present is the fact that middle managers, by and large, are not being trained and tested in risk-taking decisions. Hence, when moved into top management, middle managers suddenly find themselves up against decisions they have not been exposed to before. This is the major reason why so many fail when they reach the top.

The computer will force us to develop managers who are trained and tested in making the strategic decisions which determine business success or failure.

I doubt that the computer will much reduce the number of middle management jobs. Instead the computer is restructuring these jobs, enabling us to organize work where it logically belongs and to free middle managers for more important duties.

For instance, by tradition a district sales manager had three jobs.

He was expected to train and lead a sales force. This was his main job—on paper. In reality he gave very little time to it.

For he was also an office manager, handling a lot of paper work—bills, credits, collections and payroll. Then he usually had a big job running a warehouse and taking care of the physical movement of merchandise to customers in his district.

Now the computer makes it possible to centralize all paper work in the head office—bills, payroll, invoices, credits, shipping instructions. We can print out computer-handled paper work any place in the world from a central computer.

At the same time, the computer makes possible a sharp cut in the number of warehouses. For the computer can handle all inventory as one inventory, no matter where it is.

DO YOU NEED 50 WAREHOUSES?

The computer, therefore, can supply customers from a much smaller number of warehouses and with a very much smaller inventory. There is no longer any reason why, in most businesses, a warehouse needs to be in the same place as the district sales office. We may have 50 district sales offices, but need only eight warehouses—and only one location for all paper work.

This frees the district sales manager for the job that always should have been his main preoccupation—managing the sales effort.

In other words, the computer enables us to structure according to need. In the past, corporate structure was largely determined by geography and the

limitations on information. This is no longer necessary. We can now decide how we want to set up the business.

We can build decision centers where the decisions are best made, rather than where geography and absence of information force us to locate.

More than likely, this will mean that more people will have decision-making authority, simply because more people can get the information they require to make the decision.

At the same time, the computer will enable top management to insist that decisions be made as decisions and with proper thought and understanding. It will, above all, enable top management to insist that alternatives are thought through, including what to do if the decision does not work out.

With the computer and its ability to process information fast, there is no reason why alternatives should not be worked out in advance.

ADVICE TO MANAGERS—GET SMART

There are good reasons why managers better learn fast what the computer can do for them and what it cannot do. For the developments in computer use just ahead will make it a much more common, more usable and more widely used tool. It will also be a much cheaper tool.

The costs of storing as well as the costs of computation per unit will tomorrow be only a fraction of what they are today; and they are today only a fraction of what they were a few years ago.

Four developments in particular deserve mentioning:

Time sharing: We now realize that we can design and build computers of such capacity that a great many users can use them at the same time, each for his own purpose. We can, in other words, make the computer a public utility into which almost any number of users can plug in simultaneously.

It is quite possible that in 10 or 20 years, individual businesses will no more run and own their own computers than individual businesses today own and run their own electric power-generating stations. Sixty years ago practically every plant had its own powerhouse. Now we just plug in and get the power directly on a time-sharing basis from a public utility.

Information is going to become a public resource and a public utility. It is the oldest resource of man, in one way, but it is also the newest. Its becoming available to everyone for a very low cost will mean a virtual revolution in information.

Almost certainly within the next 10 years we will have on the market a small appliance that can be plugged in like the radio or the TV set—or into the telephone—which will enable any student from the first grade through college to get all the information he needs for his school work from a centrally located computer. Such universal access computers are even now being installed in quite a few colleges.

Closely connected with this is the rapid development of terminal and accessory equipment, equipment that enables the computer information to be used anyplace, and, in turn, makes it possible to put data into the computer from any point.

In 10 or 15 years data transmission will be as common as voice transmission over the telephone. Data transmission long distance is already growing much faster than ordinary long-distance telephone calls. This means fast printers, two-way sets, for instance, that enable a branch office to get all the information it needs immediately from its central computer and, in turn, to feed into the computer every thing that happens in the branch office.

Equally important is the rapid increase in our capacity to translate from geometry into arithmetic, that is, from graphics into binary codes.

There is a great deal of work to be done in this field. But it is not work on computer design. It is work on understanding graphic patterns.

We cannot yet analyze the millions of cloud photographs weather satellites take each day. But not because we cannot translate these cloud pictures into computer language. The reason is simply that we do not yet know enough about the weather to know what we are looking for in the pictures.

We cannot tell the computer what to do. But if we could, the computer would do it. Increasingly, we will learn to make use of this capacity to go from one kind of mathematics into another. Increasingly, we will be able to analyze visual material in terms of its logic and to present logic (for example, an equation) in visual form.

This will have tremendous impact on our ability to control manufacturing processes through direct observation. It will have tremendous impact on our ability to design physical structures of all kinds.

DOING AWAY WITH PROGRAMMERS

Finally, we will become less and less dependent on the programmer. We will be more and more able to put information into the computer directly in something akin to ordinary language and to get out of the computer something akin to ordinary language.

Today the programmer has to translate from ordinary language into the computer code.

This is the greatest limitation of the present system. It cuts the computer's speed down to the speed of a human being—and this, in handling logic, means it cuts it down to a very slow speed. It also creates the need for employment of many essentially unskilled people. Yet on their skill and understanding the ability of the computer to perform depends altogether.

To the extent to which we can jump the programing stage and get closer to computers able to handle information directly, to that extent will the computer become more effective, more flexible and more universal.

The idea that it will master us is absurd—one can always pull the plug and cut it off anyhow. But it is a tool of tremendous potential, if used properly.

It cannot, and it will not, make decisions. But it will greatly multiply the ability, the effectiveness and the impact of those people of intelligence and judgment who take the trouble to find out what the computer is all about.

READING 14 DISCUSSION QUESTIONS

1 (a) What can computers do for businessmen?
(b) What are the limitations of computers?
2 What four developments in computer usage does Drucker see in the future?
3 (a) Identify and discuss the two kinds of tools which man has developed.
(b) Into which category does the computer fall?
2 What does Drucker see as the "greatest limitation" of the present systems using computers?

READING 15 THE COMPUTER COMES OF AGE*

NEAL J. DEAN

The survey to be reported on in this article is the second such study made by Booz, Allen & Hamilton Inc.[1] The 108 manufacturing companies covered were selected on the basis of their superior records of sales growth and return on equity compared to the averages for their industries. Every significant manufacturing industry group was included. The companies' experience with the computer ranged from one to eighteen years. Annual sales volumes ranged from under $50 million to more than $10 billion. Both centralized and decentralized companies participated. The manufacturing processes of the companies included "continuous process" companies which convert raw materials into finished products by a flow-through process, "fabrication and assembly" companies which build discrete finished items from component parts, "industrial products"

*Reprinted from *Harvard Business Review,* vol. 46, no. 1, pp. 83-91, January-February, 1968. Reprinted by permission from *Harvard Business Review.* Mr. Dean is a vice-president of Booz, Allen & Hamilton Inc., and is in charge of that firm's management systems group.

Author's note: The research for this study was conducted by Leroy S. Brenna and James M. Beck.

[1] The first was reported by Neal J. Dean and James W. Taylor in "Managing to Manage the Computer," HBR September-October 1966, p. 98.

companies which make products that are used largely by other businesses and by the federal government, and "consumer products" companies which make items used by the general public.

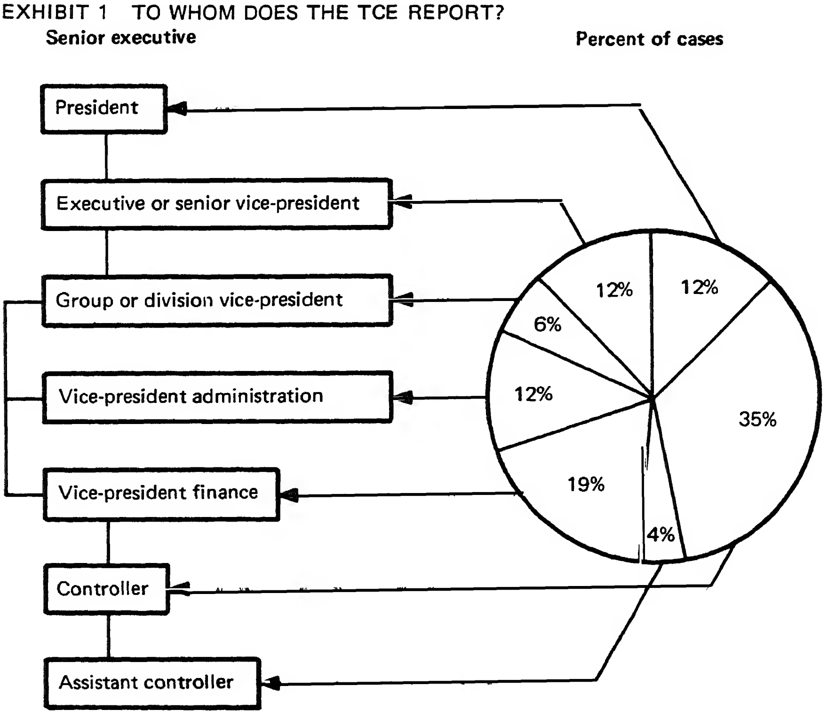
EMERGENCE OF THE 'TCE'

A significant finding of the study is the emergence of the top computer executive (TCE). In one way or another, this man is responsible for the company's computer effort. He typically coordinates the activities of other computer managers and is responsible for overall quality, performance, and forward planning in the company's computer effort. In almost all instances, the TCE is found at the corporate level, and most managements seem to feel that it is absolutely necessary that he have considerable power. As one TCE said:

"You must have centralized direction as well as centralized coordination if you expect to manage information systems successfully. Centralized coordination alone without corporate direction wouldn't give us the compatibility of systems that we must have to compete effectively in today's market."

Of the 108 companies covered in this survey, 97 have established such an executive position. As shown in Exhibit 1, a TCE is found in different reporting

EXHIBIT 1 TO WHOM DOES THE TCE REPORT?



relationships in these companies. This relationship tends to be determined by the general pattern of organization in each firm. In about one third of the companies, the TCE reports to corporate controllers; in the remaining two thirds, he reports directly to a president or vice president who, in turn, reports directly to the president.

The TCE performs his role in ways similar to those of other top corporate executives. As shown in Exhibit 2 he may direct all computer activities on a centralized basis, or provide overall direction to decentralized computer groups—or do a little of both, if the company organization pattern contains elements of both centralization and decentralization. Whether his management is direct or through other managers, he is expected to be on top of all computer activities in the company program. An oil company executive made this comment:

"Centralized control and decentralized operations of data processing is our present practice. We had a lot of duplication of effort, so we decided to centralize the control of our computer effort. This move runs counter to the basic organizational philosophy of the company. But we are attempting to seek equilibrium by decentralizing control over expenditures and by adding to the autonomy of operations."

A key part of the TCE's job is working with noncomputer executives, who are becoming more and more involved in specifying what the computer is to do for them. This is particularly true because of the increasing trend toward participation of functional, divisional, branch, and plant operating executives in creating short-term systems-development plans. The TCE also works increasingly with the chief executive officer—president or chairman—on the company's overall use of the computer both in current operations and longer-term programs.

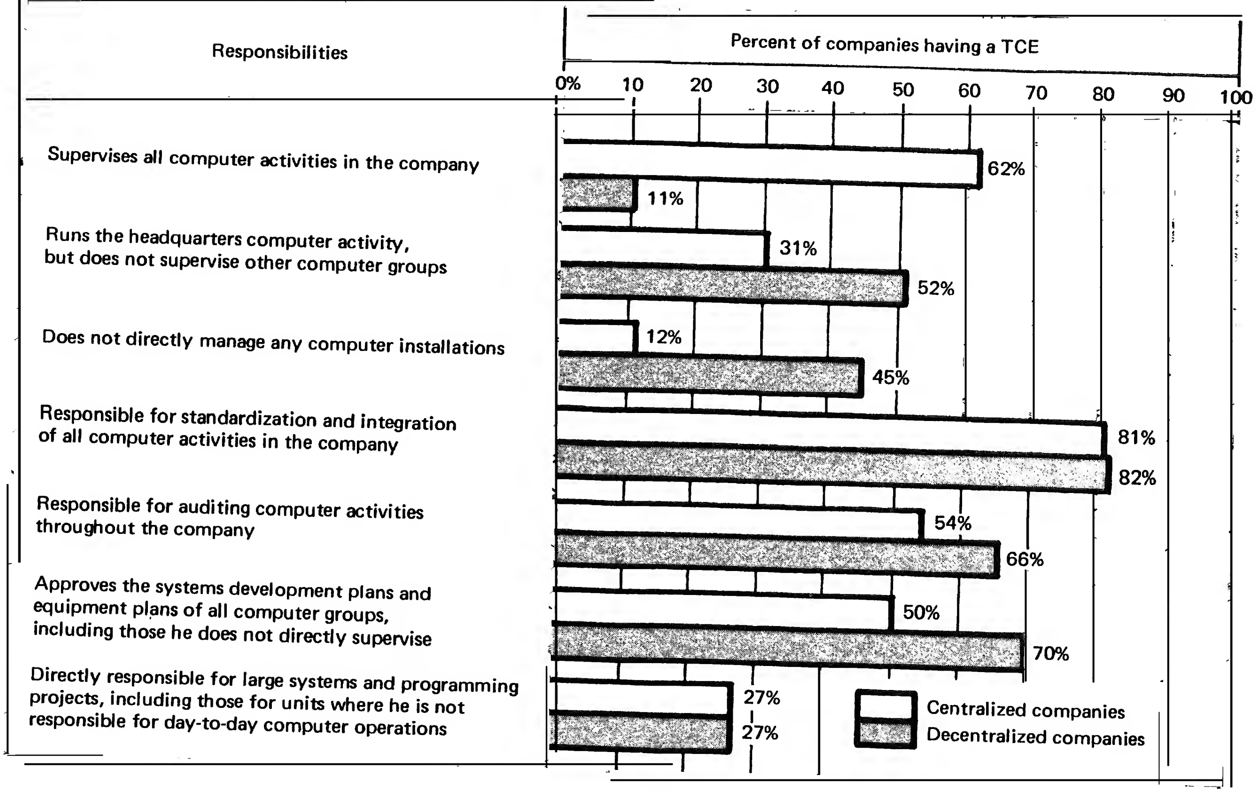
ACTIVITIES MANAGED

The TCE, more often than not, is responsible for activities other than the computer activity. In fact, in only 32 companies out of the 108 surveyed are his responsibilities limited to computer activities. His other activities often include operations research, clerical systems and procedures, and even, in a few instances, broad corporate planning activities.

The study shows that 48% of the TCEs supervise operations research (OR) groups. Clerical systems and procedures are the next most commonly found noncomputer activity of TCEs, with 46% of them having responsibility for this function.

It used to be the practice to assign responsibility for computer activities to a financial executive (or an executive whose responsibilities were largely financial in character). Today, however, only about one tenth of the companies with specifically established TCE positions make financial planning and financial auditing a part of the TCE's responsibility.

EXHIBIT 2 WHAT ARE THE TCE's RESPONSIBILITIES?



LOCATION PATTERNS

Decentralized companies tend to have most or some of their computer operations and systems analysts at division, branch, or plant locations. But in a large number of the centralized companies, too, the responsibility for some computer activities is decentralized (see Part A of Exhibit 3). There is clear recognition in these companies that their interests are best served by having the computer where it can directly support company operations.

The dichotomy of having companywide central control and decentralized computer operations has been reconciled in a pattern commonly found in certain other company functions. In both centralized and decentralized companies, there are computer systems planning and development at the corporate headquarters level. These are the computer systems developers—planning personnel, systems analysts, and programmers. This group assures coordinated development of systems and consistency of hardware and software throughout the organization (see Part B of Exhibit 3).

The computer systems operating personnel—computer operators, keypunchers, and electronic accounting machine (EAM) operators—working under the direction of this headquarters group, are more commonly found in the divisions, branches, and plants than are the planners and analysts (as shown in Part C of Exhibit 3). An interesting indication of the importance of on-site computer operations activities is the fact that clerical systems and procedures specialists are less commonly found at branches, divisions, and other decentralized operating locations than are their opposite numbers, the computer systems analysts.

A little more than one third of the companies in this study have computers in foreign countries. The mix of computer people at various locations in these foreign countries generally is similar to that in domestic operations. Those capabilities involved in operating the computer are more commonly found in the operating divisions and plants, while the planners and systems developers are typically located at the foreign headquarters level or at corporate headquarters in the United States.

SPECIALIZED FUNCTIONS

Many companies use computers for specialized purposes—that is, for activities other than processing business information. Often these groups have their own systems and programming staffs, and may operate their own computers as well, depending on the nature of the type of data and hardware requirements involved. For instance, separate systems and programming staffs for research, development, and engineering (RD&E) are found in 65% of the surveyed companies, and 39% have separate RD&E computers. The larger the company, the greater the likelihood that the RD&E organization will have its own computer, as shown in Part A of Exhibit 4.

EXHIBIT 3 LOCATION OF COMPUTERS AND PERSONNEL

A. Where is the equipment located?

Location	Percent of companies having computers at indicated location: Centralized	Decentralized
Headquarters	93%	70%
Domestic divisions or plants	57	91
Foreign subsidiaries or branches	16	42

B. Where do the systems analysts work?

Location	Percent of companies having systems analysts at indicated location: Centralized	Decentralized
Headquarters	93%	89%
Domestic divisions or plants	43	81
Foreign subsidiaries or branches	16	42

C. Where do other specialists work?

Specialists	Percent of centralized companies employing the indicated specialists at: Headquarters	Domestic branches/plants	Percent of decentralized companies employing the indicated specialists at: Headquarters	Domestic branches/plants
Planners	100%	36%	95%	68%
Analysts	93	43	89	81
Programmers	93	46	79	94
Computer operators	93	57	70	91
Keypunchers	93	64	70	95
EAM operators	86	57	57	89
Clerical S&P	79	39	68	76

EXHIBIT 4 COMPUTER USE FOR SPECIAL PURPOSES

A. How widespread is RD&E specialization?

	Percent of companies having RD&E systems and programming groups	Percent of companies having RD&E computers
All companies in survey	65%	39%
By sales volume*		
Up to $99 million (9)	33	0
$100 million to $199 million (16)	50	21
$200 million to $499 million (23)	75	35
$500 million to $999 million (21)	55	40
$1 billion and over (39)	85	65

B. How widespread is specialization in process control?

	Percent of companies having process-control systems and programming groups	Percent of companies having process-control computers
All companies in survey	28%	25%
By type of industry*		
Continuous process (65)		
Industrial products (33)	38	38
Consumer products (32)	41	41
Fabrication and assembly (43)		
Industrial products (27)	9	0
Consumer products (16)	20	13

C. What is the extent of specialization for numerical-control programming?

	Percent of companies having numerical-control systems and programming groups	Percent of companies having numerical-control computers
All companies in survey	17%	5%
By type of industry*		
Continuous process (65)		
Industrial products (33)	17	7
Consumer products (32)	0	0
Fabrication and assembly (43)		
Industrial products (27)	30	9
Consumer products (16)	20	0

*Numbers in parentheses refer to number of companies in category.

In those companies that have separate OR groups, the group often includes systems analysts or programmers. However, only three companies have separate computers specifically for OR purposes. Most OR computer work is done on business data processing equipment or on RD&E computers; little work is done on analog computers.

As might be expected, the percentage of companies which have a separate process-control computer capability is much higher for process-oriented industries than for fabrication and assembly industries (see Part B of Exhibit 4).

At present, process-control computers are usually the responsibility of that operation of the firm in which they are used, such as a production unit or a research laboratory. However, there is a growing recognition that process-control computers can be a source of data for regular business computers. As systems integration progresses, process-control computers undoubtedly will come under increasing control, if not within the direct responsibility, of the TCE.

Part C of Exhibit 4 shows that machine tool numerical-control programming is being done on computers in 17% of all the companies—in most cases, on normal business data processing computers.

VARYING COST PATTERNS

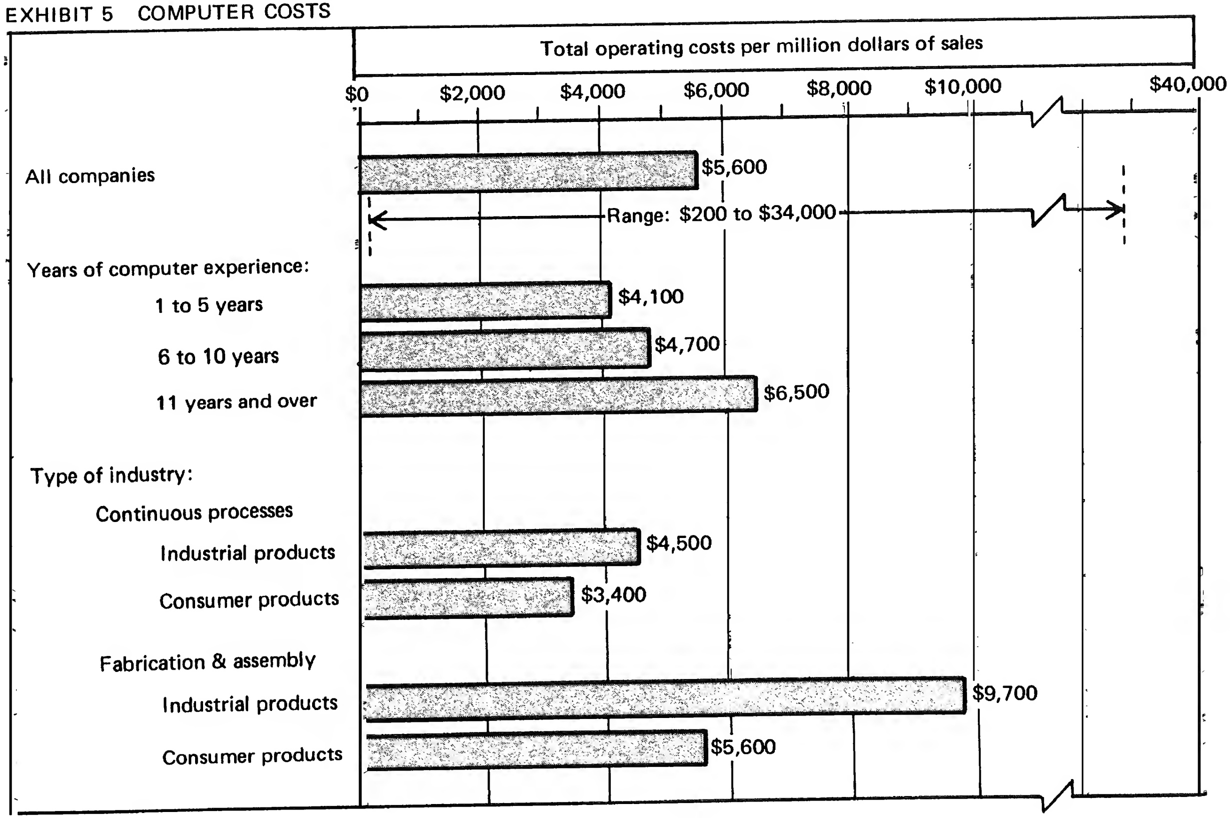
The amount of money spent in using the computer, and the way the money is being spent among the different activities in computer operations, varies by length of computer experience and sales volume of the individual company. As for the future, only four companies in the survey expect computer costs either to hold at the present level or to decline.

The longer a company has been using its computer, the more money it spends on this operation; the median for all companies in the survey now stands at $5,600 per $1,000,000 of sales volume. Around this median, individual company computer costs ranged from $200 per $1,000,000 of sales for a crude-oil refiner which was just launching a computer operation, to $34,000 per $1,000,000 of sales for a large aerospace company (see Exhibit 5). Smaller firms and firms with relatively short computer experience spend less on systems planning and programming than do the companies that are larger and have longer experience.

Another common factor among all companies surveyed is that they spend more money on equipment rental and other operating costs than they do on systems planning and programming. The average expenditure for all companies for systems planning and programming is 29% of computer costs; equipment rental accounts for 38% of costs, and other computer operating expenses come to 33% of the total.

Increasing costs for systems planning and programming are consistent with historical patterns established by companies that have made successful use of data processing capabilities.

EXHIBIT 5 COMPUTER COSTS



When a company initially acquires a computer, its primary need is for programming personnel to convert existing systems to the computer. Later, it obtains systems analysts to improve the already converted systems and to develop new computer-based systems to improve the efficiency and profitability of company operations. However, it is not uncommon for a company to establish a considerable number of systems analysts in separate groups *without coordinating their efforts.*

So, when companies recognize the high cost of duplicate systems, they frequently acquire planning personnel to coordinate the efforts of systems analysts and to ensure standardization of practices and procedures in data processing systems. Professional systems analysts and planning personnel then recognize and move into the more sophisticated systems that need to be developed. For example, operations research personnel may be employed to put mathematical techniques to use as an essential ingredient for capitalizing fully on the benefits of the computer. This sequence accounts for the trends of the figures in Exhibit 6.

INCREASING USE

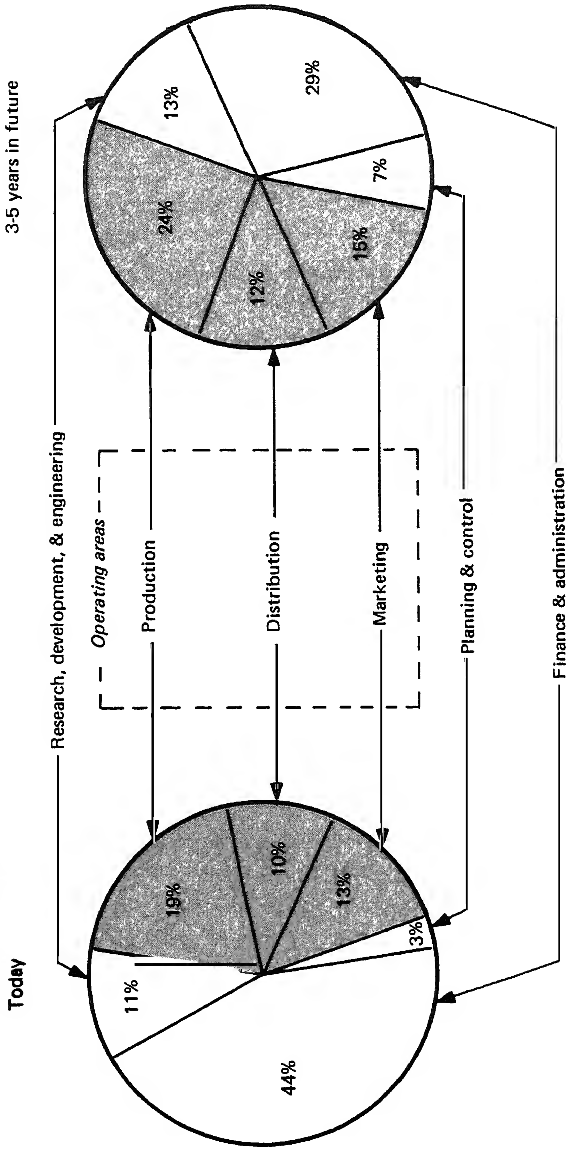
The study clearly indicates a trend away from restricting the computer to finance and administration. It is used more and more often in major operating areas—marketing, production, and distribution. In the next three to five years companies in the survey expect to direct over half of the total computer effort to serving operating areas, and company executives expect to double the proportion of effort given to planning and control (see Exhibit 7). This trend toward more emphasis on applications in operating functions is more pronounced as a company's years of computer experience increase.

The study reveals some interesting differences in emphasis among various types of applications within industry groups. These variations directly reflect the characteristics of different types of business and the recognition that different functional areas are critical to a company's success. For example:

EXHIBIT 6 USE OF FUNCTIONAL SPECIALISTS AT DOMESTIC DIVISIONS

	Percent of companies employing specialists in:			
	Programming	Systems analysis	Planning	Operations research
All companies in survey	78%	69%	57%	48%
By years of computer experience				
1-5 years	57	52	43	33
6-10 years	78	66	47	48
11 or more years	90	82	74	54

EXHIBIT 7 HOW IS COMPUTER USE EXPECTED TO CHANGE?



In fabricated and assembled products companies, RD&E computer applications represent 18% of the computer effort, and manufacturing or factory applications account for 24% of the computer effort; by contrast, the comparable percentages are 7% and 14% respectively in continuous-process companies. This difference reflects the contrasting requirements of product engineering, production, scheduling, and control in the two types of businesses.

In consumer goods industries, computer applications in marketing account for 16% of total computer effort, as compared to 11% for companies producing industrial products.

SYSTEMS INTEGRATION

The median company in the survey now has some computer systems which are integrated within functional areas; that is, major data processing systems within a function (such as marketing or production) are linked together, coordinated, and run as a unit. In three to five years, the median company expects to have integrated systems which tie together two or more functional areas. And, in the future, all companies in the sample expect their computer systems to be integrated to some significant degree, as shown in Exhibit 8.

Predictably, computer systems in decentralized companies are less integrated now than in centralized companies primarily because of the complexities of multiplant and multiproduct activities. But, the survey shows, in three to five years both centralized and decentralized companies expect to be at about the *same* level of integration of computer systems. In other words, the decentralized companies expect to overcome most of the difficulties of standardizing and integrating diverse and independent product groups.

Most of the companies (82%) also regularly prepare long-range plans to guide their computer activities. The most common time span for long-range plans is three to four years. About a quarter of the long-range plans reported in the survey cover five years or more.

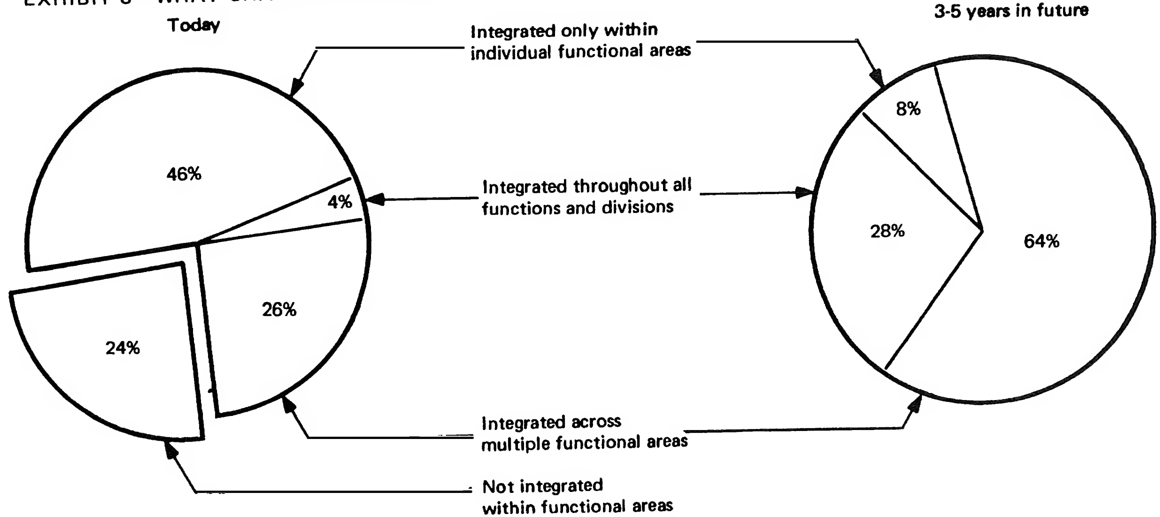
As part of their long-term planning, many companies are investigating the pros and cons of eventual integration of computer activities into total "management information systems." However, most of the companies, including many of those with the longest computer experience, do not intend to go that far in the next three to five years.

PLANNING AND CONTROL

Executives of 90% of the companies say they maintain planning and control of their computer operations by the use of a formal short-range plan. Of these companies, over half include in the plan costs and schedules for all projects, while the remaining companies include costs and schedules for major projects only.

Short-range computer plans are an important control mechanism in all of the companies in the survey. In more than two thirds of the companies, in fact,

EXHIBIT 8 WHAT CHANGES ARE EXPECTED IN THE DEGREE OF INTEGRATION OF COMPUTER SYSTEMS?



short-range plans are the most significant control device for management. In the remaining third, short-range plans are used primarily as guidelines.

Nearly all of the companies in the survey use some measure of relative profit improvement as a means for choosing among different systems projects proposed for consideration. Formal return-on-investment analysis is the major criterion in 24% of the companies, less formal analyses of operating improvement are used in 61% of the cases, and direct cost reduction or other measures of selection are used in the remaining companies.

AUDITING ACTIVITIES

The managements of two thirds of the surveyed companies use regular audits to improve their control of computer activities and performance. The larger the company, the greater the likelihood that management regularly audits computer work. Of increasing significance is the degree to which operating managers are involved in making these audits. The managers typically serve as members of a committee that reviews the findings of the audit and reports to top divisional and corporate executives.

Of the companies that perform regular audits, most (62%) confine their audits to critical computer applications, while the others (38%) cover all areas of computer activity. In the companies performing audits of either type, there is a major emphasis on the following activities (numbers in parentheses refer to the portion of the sample engaged in the activity):

- Appraisal of budgets for new computer systems developments and new equipment (78%).
- Determination of appropriateness of present systems as management and control tools (75%).
- Review of the usefulness of present systems to operating people (70%).
- Checking on adherence to operating budgets and output deadlines (67%).
- Analysis of systems and operations for potential susceptibility to fraud or other financial irregularity (63%).
- Evaluation of personnel and management practices affecting computer systems (62%).
- Review of adherence to development project budgets and schedules (60%).

CONCLUSION

The computer systems function, not only technologically but also managerially, has come of age. As a result, it has become an extraordinarily important quantitative tool at the disposal of management at all levels in the intense competitive market which manufacturing companies in the United States face today.

The survey clearly shows that the computer increasingly is penetrating and permeating all areas of major manufacturing corporations. Indeed, the computer is becoming an integral part of operations in those companies. Several findings give solid evidence of this. Most of the companies in the survey are expecting to increase their financial commitments for computer services at a rate which is more rapid than their anticipated annual sales growth. In addition, and because of these increasing financial commitments, the chief executive officers are taking a more active role in the computer function of their companies. Increasingly, other levels of management—operating group as well as staff groups—are also participating in planning for computer usage.

Along with this increasing involvement in money and manpower, the computer activity is becoming a more integrated and established part of company operations. Computers are being used more and more for management planning and control as well as for record keeping. More companies are using OR and advanced mathematical techniques in computer operations.

Accepted management techniques typically used in other parts of company operations are being applied to the computer function. Companies are planning, budgeting, and auditing the computer function. More and more often, computer project selection is being made on the basis of overall benefits to the company. Also, the growing number of TCEs at high levels of responsibility in the corporate structure attests to growing recognition of the importance of computer management.

In reporting Booz, Allen & Hamilton's first study of computer management, an executive was quoted as saying: "Our real goal is to make sure that we achieve more benefits from computers than our competitors do."[2] This kind of aggressive, competitive thinking has doubtless played a large part in speeding the development of computer systems. It also spells a real threat for laggards in such development, for it means that the gap between effective users, on the one hand, and ineffective users and nonusers, on the other hand, will widen ever more swiftly. The day may not be far distant when those who analyze annual business failures can add another category to their list of causes—failure to exploit the computer.

READING 15 DISCUSSION QUESTIONS

1 "The computer systems function, not only technologically but also managerially, has come of age." Discuss this statement.
2 Why are the chief executive officers now taking a more active role in the computer function of their companies?
3 How do the firms studied expect computer use to change in the future?
4 What changes are expected in the degree of integration of computer systems?

[2] *Ibid.*, p. 99.

SUMMARY OF CHAPTER 3

Management is the process of achieving organizational objectives through the efforts of other people. To manage effectively, managers are required to perform the managerial activities of planning, organizing, staffing, and controlling. These activities are interrelated; in practice, a manager may be carrying out several functions simultaneously.

The decision to introduce and use computers in an organization has managerial implications which go far beyond the mere acquisition of a piece of technical equipment. Careful planning is required to introduce a computerized information-processing system. In the past, top executives have failed to actively participate in this project, and the results which have been obtained in many cases can only be described as marginal. Readings 11 and 12 verify this fact.

Once a computer is introduced into an organization, its use can improve planning and control by providing effective information which (1) leads to problem awareness, (2) supports problem analysis and selection of alternatives, (3) influences the choice of the most appropriate option, and (4) permits feedback on the implementation of decisions. Computers can also be used to apply new decision-making techniques to business problems. In addition, computer usage has organizational implications (the entire organizational structure may undergo stress and alteration), staffing implications (the nature and number of jobs may be affected), and economic implications (the investment in computer systems often increases at a more rapid rate than does the growth in annual revenue).

In the chapters that follow, we shall examine some of the managerial problems associated with the introduction and use of computers. In so doing we shall focus attention on the impact which computers have had, are having, and may be expected to have on managers and on the environment in which they work.

PLANNING FOR COMPUTERS

The following verse points out the major areas of planning for computers. (It also points out one result—there are many others—of inadequate planning.)

THE INFORMATION SYSTEM* Marilyn Driscoll

[CANTO THE FIRST: PROPOSAL]
"An information system," said the president, J.B.,
"Is what this company sorely needs, or so it seems to me:
An automated, integrated system that embraces
All the proper people, in all the proper places,
So that the proper people, by communications linked,
Can manage by exception, instead of by instinct."

[CANTO THE SECOND: FEASIBILITY STUDY]
They called in the consultants then, to see what they could see,
And to tell them how to optimize their use of EDP.
The consultants studied hard and long (their fee for this was sizable)
And concluded that an information system was quite feasible.
"Such a system," they reported, "will not only give you speed,
It will give you whole new kinds of information that you need."

[CANTO THE THIRD: INSTALLATION]
So an information system was developed and installed
And all the proper people were properly enthralled.
They thought of all the many kinds of facts it could transmit
And predicted higher profits would indeed result from it;
They agreed the information that it would communicate
Would never be too little, and would never be too late.

*From *The Arthur Young Journal,* p. 38, Winter, 1968. Copyright 1968 by Arthur Young & Company and reprinted with permission. Marilyn Driscoll is a secretary in the home office of Arthur Young & Company.

[CANTO THE LAST: OUTPUT]
Yet when the system went on line, there was no great hurrah,
For it soon became apparent that it had one fatal flaw:
Though the system functioned perfectly, it couldn't quite atone
For the information it revealed—which was better left unknown.

In planning for computers, the first major question to be studied is the feasibility of using a computer to achieve company goals. *Technical, economic,* and *operational* aspects should be evaluated in such a study.[1] In a technical sense, most proposed business systems are feasible; the job *can* be done; hardware and software exists (or can be prepared) to implement the systems. Whether such implementation would be economical, of course, is another matter which should be evaluated. Finally, a system may fail to achieve company goals (even though it is technically and economically feasible) if company personnel are not sold on it and do not want to make it work. We shall briefly look at technical and economic aspects in this chapter. Operational aspects will be deferred to Chapter 6.

More specifically, in this chapter we shall first examine the *essential nature of the feasibility study*. We shall then look at a *feasibility-study approach.*[2] Assuming that computer acquisition is judged to be desirable, a second major planning effort must be made to prepare for the new systems. In the latter pages of this chapter we shall summarize the *conversion steps* which must be taken to develop and install these new systems.

ESSENTIAL NATURE OF THE FEASIBILITY STUDY

A *feasibility study* is the investigation made by an organization to determine the desirability of using a computer to achieve *specific* objectives. There are at least three reasons for making such a study. First, as we saw in the closing paragraphs of the last chapter, substantial investment may be involved in the computer decision, and *a proper study reduces the risk of loss*. Second, many of the common *pitfalls associated with inadequate planning may be avoided*. Finally, *the study may point the way to substantial benefits.*

[1] See the reading entitled "Plain Talk About Computers" at the end of Chap. 2.
[2] We shall emphasize the approach to be followed by businesses considering their *first* computer; however, much of the material to be presented will be equally applicable in determining the feasibility of converting to another hardware system.

REDUCING ECONOMIC RISK

Computer usage seems to be justified only when one or more of the following conditions is present:

1 When greater processing speed is both desired *and necessary*
2 When complexities of data processing require electronic methods
3 When computer investment is offset by tangible or intangible[3] economic benefits

The last of these conditions is of paramount importance to a business, for as Richard H. Hill, vice-president of Informatics, Inc., has observed: *"A computer installation in an economic enterprise can never be justified except in economic terms."*[4]

Yet there are numerous examples of businesses which *have not* achieved any economic gains from their computers. To illustrate, one authority has estimated (1) that about 40 percent of all computer-using organizations have not received economic benefits equal to their investments; and (2) that this 40 percent "failure" rate may be expected to continue for the next five years. He goes on to say that "it has further been estimated that some 90 percent of all new data-processing installations exceeded their initial budget and failed to meet their installation schedule."[5] Benjamin Conway, a senior systems consultant with IBM, concludes that almost invariably costs are understated, savings are overstated, and, without tight control, the savings which are actually possible tend to melt away.[6]

The gloomy facts just presented support the contention that computer acquisition can be risky. The costs associated with acquiring a computer can be hard to predict. The difficulty is not caused by hardware rental or purchase costs, for such costs are known. Rather, the difficulty is caused by the unpredictability of software and operating costs (which are likely to be larger than hardware costs). And, of course, when expenses are hard to pin down, tangible savings resulting from computer usage become equally difficult to

[3]John Diebold points out that new investment criteria should be developed in the future for allocating resources to emerging management information systems. In addition to the usual considerations of *cost-displacement* to be discussed below, future criteria should give more weight to *operational gains*—i.e., efficiencies resulting from inventory reductions and faster production—and to the *intangible benefits*—i.e., better planning and forecasting, and improved customer service—which are possible with computer usage. See John Diebold, "Bad Decisions on Computer Use," *Harvard Business Review,* pp. 14-16ff, January-February, 1969.

[4]Richard H. Hill, "Computer Economics," *Data Processing Digest*, vol. 12, p. 3, May, 1966.

[5]See Dick H. Brandon, "The Need for Management Standards in Data Processing," *Data & Control Systems*, p. 27, September, 1966.

[6]See Benjamin Conway, "The Information System Audit: A Control Technique for Managers." This article appears in the readings section at the end of this chapter.

predict. A properly conducted feasibility study will not eliminate economic risk, but it can substantially reduce it.

AVOIDING COMMON PITFALLS

We have just seen that financial loss may be an *end result* of failure to conduct an appropriate feasibility study. In the past, numerous mistakes made by managers have contributed to this undesirable end. These same snares will undoubtedly serve as the future *means* by which unwary managers (through their failure to conduct a proper study) will bring about economic losses for their firms. Several of the more *common pitfalls to be avoided are presented below:*

1 *Lack of top management support* As noted in Chapter 3, converting to a computer carries with it many managerial implications of a nontechnical nature. In the past, top executives have often failed to provide the needed leadership.

2 *Failure to specify objectives* A feasibility study should be directed toward achieving *specific* objectives. It is the responsibility of managers to specify what they want in the way of quality management information. A computer should be considered *only* when the study indicates that goals can best be reached by electronic means. Failure to specify needs and objectives is a planning blunder which occurs more often than might be expected.

3 *Excessive reliance on vendors* Computer manufacturers can provide many valuable services. But it is unrealistic to expect them to be objective if (as has sometimes been the case in the past) they are given the job of conducting the feasibility study.

4 *Lack of awareness of past estimation-error patterns* The following error patterns are among those which have been common in the past: (1) initial program preparation time and difficulty of training programmers has generally been underestimated; (2) the degree of employee resistance to change has been "surprisingly" high; (3) program running times have been unexpectedly long (this error can lead to the selection of inadequate hardware); and (4) costs have been understated while savings estimates have been too optimistic.

5 *The crash-program pitfall* It typically requires from 15 to 30 months to complete an initial conversion to a magnetic tape computer system. Yet it is not uncommon for managers to attempt a crash program in much less time because (1) they don't appreciate the magnitude of the task; (2) they have neglected the old system until an urgent solution is needed; (3) they wish to achieve immediately the benefits which the computer is supposed to provide; and (4) they can get hardware delivery in, perhaps, six months, so this future date arbitrarily dictates the conversion time available. The data-processing system produced in a crash program generally leaves much to be desired. It often fails to meet company needs; it requires that a disproportionate amount of time be taken to correct errors and oversights; it encounters resistance from personnel

who were not properly prepared for it; and it costs more to operate than had been expected.

6 *The hardware-approach pitfall* Executives have been known to contract for a computer first and then to decide on how it can be used. The hardware approach typically dispenses with any meaningful feasibility study; an elusive intangible called "prestige" is its goal; and the effects of change on personnel are given little consideration.

7 *The improper-priority pitfall* One of the consequences of a lack of top management support and of failure to specify objectives clearly has been that critical application areas have been ignored. Processing emphasis is placed on lower-priority tasks. A thorough feasibility study should identify the critical functions.

8 *The piecemeal-approach pitfall* During a feasibility study, careful attention should be given to *redesigning* systems for greater efficiency. Excellent results are seldom achieved when manual records are simply converted and processed on a computer. Yet failure to redesign applications has been common. Although a step-by-step[7] approach to system integration is followed by most firms, new systems which will impede future consolidation efforts should not be designed. Also, the newly designed systems should incorporate, whenever possible, externally produced data.

9 *The inadequate-staffing pitfall* Members of the study team should have an intimate knowledge of the business, and/or they should be competent in the technical aspects of systems and data processing. Although their talents are often in demand elsewhere in the organization, these people must be released from other duties if a proper study is to be made. Entrusting the study effort to an "average" group yields only average results at best.

STUDY BENEFITS

A primary benefit of the feasibility study is that it enables a company to steer clear of many of the pitfalls described above and is thus able to reduce the possibility of financial loss. In addition, the *time and money invested in a feasibility study may yield the following benefits:*

1 *Current systems savings may be achieved* by the cleaning up of outdated procedures which have evolved over long periods of time. Obsolete reports and duplication can often be eliminated; significant cost reductions may thus be possible regardless of whether or not a computer is installed. In fact, it is likely

[7] The step-by-step approach is the strategy of converting specific applications to the computer while moving gradually toward greater integration. Although integration is generally desirable, some firms have attempted studies which were *too broad* in view of their personnel and financial resources.

that the cost reductions attributed to many computers are more probably the result of systems improvement.

2 *A healthy reevaluation of company purpose and goals may result.* The major problems and opportunities of the business may be made explicit, perhaps for the first time. Long-range planning is likely to be encouraged by this definition. Operating personnel may better understand what is expected of them; they may better appreciate the problems of other departments of the organization, and this appreciation can lead to better cooperation and coordination of effort.

The above pages have demonstrated the essential nature of the feasibility study in planning for computers. Let us now look at an approach to be followed in conducting such a study.

FEASIBILITY-STUDY APPROACH

A feasibility study is conducted to provide information for decision-making purposes. You will recall from Chapter 3 that the questions to be decided include (1) whether it is desirable to use a computer to achieve data-processing objectives, (2) if so, whether all computer alternatives have been considered, and (3) if an in-house installation is justified, what hardware should be selected. Answers to these and other questions will be sought during the feasibility study. In arriving at their answers, the team making the study should follow the planning and rational decision-making steps presented in Chapter 3. In other words, the steps in the feasibility study approach are to (1) *accomplish planning prerequisites and identify the objectives,* (2) *gather data on current operations,* (3) *analyze current operations and determine suitable alternatives,* (4) *decide on the most appropriate alternative,* and (5) *follow up on the decision.*

PLANNING PREREQUISITES AND IDENTIFICATION OF OBJECTIVES

The account of an early well-managed survey is found in the Bible in Chapter 13 of the Book of Numbers. A team of 12 analysts was sent by Moses to spy out the Promised Land and to report back their findings. Three *important prerequisite principles* were observed in this survey:

1 *The survey had implicit support at the highest levels.* God told Moses: "Send men to spy out the land of Canaan . . . from each tribe of their fathers shall you send a man, every one a leader among them." Such top-level support is a prerequisite.

2 *The survey team consisted of highly respected individuals.* Only tribal leaders were sent on the mission. Feasibility-study members are often selected for the offsetting talents they can bring to the job. It is common to find at least one team member who possesses a knowledge of the information needs of the business and another who is familiar with systems and the technical side of data processing. The participation of a knowledgeable auditor in the design phase so

t proper controls may be built in is a wise precaution. The team leader must e the respect of the company personnel. He should be chosen on the basis of ven managerial ability for he must plan, organize, and control the project. It is job to (1) understand the scope, purpose, and goals of the study, (2) edule and coordinate the team effort and keep interested parties informed of team's progress, (3) secure the cooperation of company employees who can tribute to the study, and (4) achieve the end objectives. Although study sonnel are generally employees of the organization, it is possible to employ ependent consultants to perform the investigation.

The scope and objectives of the survey were clearly stated. Moses cifically told the 12 to investigate the richness of the land, the physical and merical strength of the occupants, and the defensibility of their cities. In a sibility study, the nature of the operation(s) which is (are) to be investigated uld also be specifically stated at the outset; the relationship of the study to er company projects should be noted; the organizational units in the mpany which are to be included and excluded should be identified; the ponsibility for survey review must be established; and the degree to which orts should be made to consolidate data-processing procedures should be rified. Following the definition of the study's scope and direction, it is then portant to specify the objectives which are to be pursued. Figure 4-1

FIGURE 4-1 COMMON FEASIBILITY-STUDY OBJECTIVES

EXPENSE-REDUCTION OBJECTIVES
(Benefits of a tangible nature)

1 Reduce clerical labor expense
2 Reduce supervisory and other nonclerical labor expense
3 Reduce equipment expense
4 Reduce space and overhead expense
5 Reduce supplies expense
6 Reduce inventory carrying expense

REVENUE-RAISING OBJECTIVES
(Benefits which are usually intangible)

1 Shorten processing time
2 Increase processing capacity to expand marketing efforts
3 Acquire more accurate information
4 Acquire more comprehensive information
5 Improve operating control
6 Improve customer service
7 Acquire new information (sales analyses, cost analyses, etc.)
8 Achieve better planning through the use of operations-research techniques

OTHER OBJECTIVES

1 Attain prestige and a progressive image
2 Meet clerical labor shortages
3 Prepare required government reports

summarizes some goals which are commonly sought. Goal selection, of course, should be based on the work that *needs to be done* and not upon the work that a computer is capable of doing. When multiple objectives are sought, priorities should be assigned to guide the study team.

The biblical survey team returned to Moses after forty days. There was agreement on the richness of the land (and this report was "documented" with examples of the fruit which it produced). There was lack of agreement, however, on the strength of the people occupying the Promised Land. Sessions were held during which the differing viewpoints were presented.

It is usually desirable for the feasibility-team members to hold preliminary sessions with the managers of all departments which the study will affect. Such *design sessions* allow the managers to participate in setting or revising specific systems goals. This participation is logical; it enables those most familiar with existing methods and procedures to make suggestions for improvement. Furthermore, these managers are the ones whose performance is affected by any changes, and they are the ones whose cooperation is needed if the study is to yield satisfactory results.

Before concluding this discussion of goal definition, it is appropriate to point out that a repeating or *iterative process* may be necessary before this first study step is considered complete. There is no definite procedure to be followed before detailed data gathering can begin. A top executive may believe that a systems study is needed because of informational deficiencies; he may prepare a general statement of objectives and then appoint a manager to conduct the study. A number of design sessions may be held to translate general desires into more specific goals; the scope of the study may be enlarged or reduced; objectives may be similarly changed as more facts are gathered. When it appears that tentative approval has been reached on objectives, the study leader should put these goals *in writing* and send them to all concerned for approval. If differences remain, they should be resolved in additional design sessions. Although repeating such sessions may appear to be unproductive to those who are impatient to get on with the study, their costs "most often end up being small relative to later costs caused by incomplete, and possibly erroneous, definition and directions."[8]

Before the more detailed investigation begins, the team leader should prepare a *written charter* for approval by the individual or group in charge of the overall data-processing program. This charter, when approved, should include (1) a detailed statement of the study's scope and objectives; (2) a grant of authority to permit the team to cross departmental lines and receive top priority on the working time of specified individuals (who should be informed of this authority

[8]Marvin W. Ehlers, "Management's Blunder Buffer," *Business Automation,* p. 40, March, 1966.

grant by a high-level executive); and (3) a schedule giving a target date for the completion of the survey recommendations and interim dates for the presentation of progress reports to the executive or steering committee in charge. (Many well-managed studies have made use of PERT-CPM networks for scheduling and control purposes.)

GATHERING DATA ON CURRENT OPERATIONS

The study-team members must first gather data on current operations before they can design suitable alternatives to achieve specified goals. In short, they must find out where they are before they can determine where they want to go. In identifying objectives, it is likely that preliminary data were gathered. But more details are now needed to determine the strengths and weaknesses of current procedures. As a result of information brought to light during this study phase, it may be desirable to revise the scope and goals of the investigation. The iterative process may be continued.

The data gathered must be accurate, up-to-date, and sufficiently complete, for they will become the input to the design stage. On the other hand, however, if the analysts are not careful, they may become so mired down in relatively unimportant details at this stage that time schedules cannot be met.[9] The data to be collected will vary from one study to another, but in most cases the following questions about the operations being studied should be answered. (1) What source information is used? (2) What work is done? (3) What business resources are being used? (4) What results are achieved? Figure 4-2 provides a list of more specific questions that may be asked in the course of gathering data.

Many well-managed firms base their ultimate decision to acquire a computer on a *return-on-investment* analysis. The profit improvement expected to result from computer usage is compared with the required hardware and software investment to see if the investment appears to be justified. Anticipated profit improvement is affected, in part, by the comparison of current processing costs with the similar costs of proposed alternatives. Thus, the team must gather data about the *current costs* to process a given volume of information. Information about processing *volume* is also needed to determine the complexity and cost of proposed alternative methods. The following cost figures related to the operations under study should be collected: (1) charges for payroll and associated fringe benefits; (2) cost of processing equipment (in the form of rental and/or depreciation charges); (3) charges for office materials, supplies, forms, etc.; and (4) overhead charges (office space used, insurance, utilities, etc.).

[9] See Richard G. Canning's excellent discussion of data-gathering problems in the reading entitled "Management of Systems Analysis" at the end of this chapter.

FIGURE 4-2 QUESTIONS FOR DATA GATHERING

WHAT SOURCE INFORMATION IS USED?

What source documents are received?
What source documents are used?
Where do they originate?
What is the frequency of input—daily, weekly, or monthly?
What is the maximum volume received? The minimum? The average?

WHAT WORK IS DONE?

What records and files are being kept to support the operation?
How frequently—daily, weekly, or monthly—is the operation being performed?
What is the volume or magnitude of work in each phase of the operation? What volume fluctuations occur in the operation? What is the cause of these fluctuations?
What is the flow of work, i.e., what sequence of steps is followed to perform the operation?

WHAT BUSINESS RESOURCES ARE USED?

What departments are involved in the operation? What place in the organization do they occupy? What is the primary function of these departments?
How many people are involved? What are their skill levels?
How many man-hours are needed?
How much time is required to complete each step?
What equipment is being used? For how long?
What materials and supplies are being used?
How much does it cost to perform the operation?

WHAT RESULTS ARE ACHIEVED?

What output reports are prepared?
What is their purpose?
Who uses the reports?
What use is actually being made of the reports?
How accurate are they?
How timely are they?

The following tools and techniques are among those which may be useful in gathering data:

1 *Design sessions* Early participation of operating managers can serve to focus attention on important areas. Furthermore, these managers represent a storehouse of information on current methods. This knowledge can reduce the analysts' data-gathering task.

2 *Systems flowcharts* Beginning with source-document inputs, each operation step is charted using the proper symbols. Files and equipment being used are identified, the processing sequence is shown, the departments involved are located, and the output results are indicated.

3 *Questionnaire forms* These forms are often keyed to steps in a flowchart.[10]

[10]The IBM booklet entitled *Documentation Techniques* is an element in that firm's Study Organization Plan series. This booklet is an excellent data-gathering guide which provides examples of useful forms.

They give the details of processing frequencies, input and output volumes, workers performing each activity, time required to complete each step, and the materials and supplies used.

4 *Personal interviews* Interviews are needed to gather the information, to prepare the flowchart, and to fill in the questionnaire forms. Interviews also serve as a check on the reliability of procedures manuals and other existing systems documentation. To verify the accuracy and completeness of interviews, an analyst may take an input document and "walk-it-through" the processing procedure. A walk-through also presents an opportunity for the analyst to obtain suggestions from employees about ways in which procedures might be improved. Interviews must be conducted with skill and tact. The analyst should (1) carefully plan his questions, (2) make advance interview appointments, (3) explain the purpose of the interview, and (4) avoid being openly critical of current approaches. He must realize, in other words, that preoccupation with technical matters at the expense of proper human relations will quickly ruin any chance of real achievement.

5 *Operational review* When the analysts feel that they have gathered all the data that is necessary, they should, as a final check on their accuracy and completeness, present these facts to operating personnel for verification and approval.

DATA ANALYSIS AND DETERMINATION OF ALTERNATIVES

During the fact-finding stage, emphasis was placed on *what* was being done; now the team is interested (1) in learning *why* these activities are being performed and (2) in designing the alternative ways in which these operations can be improved. Perhaps the first alternative which should be considered is a *modified and improved* version of present methods.[11] There are at least two reasons for updating current operations. *First,* other possible alternatives should *not* be compared with obsolete and outdated procedures. It is quite possible that an option which is attractive when compared with outdated methods might not be the best choice when compared with redesigned procedures. And *second,* an updating of current operations may prevent useless forms, reports, and records from being preserved in a conversion to an alternative.

Data gathered in the fact-finding stage are analyzed to detect weaknesses and to determine the real informational needs of the business. The team's objective here is to develop an efficient set of data-processing specifications for each area of study. Figure 4-3 lists some of the possible questions which should be answered during this review and design stage. However, the variety of different processing systems, the difficulty of describing these systems, the wide range of mechanical and electronic equipment which can be used, the speed with which equipment changes, the lack of static testing conditions caused by a rapidly

[11]This course of action might include acquiring new equipment other than a computer. Often, however, savings can be realized with little or no additional investment.

hanging business environment—all of these factors prevent the formulation of xact rules to follow in systems analysis and design. Such factors also limit the umber of alternative designs which can be manually evaluated. The questions in igure 4-3 may be presented as a *guide*. But the success of the project is

IGURE 4-3 QUESTIONS FOR ANALYSIS AND DESIGN

ROCEDURAL CONSIDERATIONS

1 Are documents being produced relevant to the needs of the business? When were they originated? Who originated them? For what purpose?

2 Is faster reporting desired? Is faster reporting necessary? Can the processing sequence be improved? What would happen if the document were delayed? If it were eliminated?

3 Is greater accuracy needed? Could less accuracy be tolerated, i.e., is the expense involved in error checking greater than the cost of committing the error? Is adequate control maintained over document preparation? Does excessive control add to expense?

4 What monetary value would the user place on the document? Would he be willing to have his department charged with part of the cost of preparation?

5 Is the document in a useful form? Has writing been minimized? When were forms designed? Who designed them? For what purpose?

6 Does an output document cause action when it is sent to a manager? If not, why is it sent? If it does, what decisions are made?

7 Is the document filed? If so, for how long? How often is it referred to? Does the filing cost exceed the value of having the document available?

8 Can documents be combined? Is the same information duplicated on other reports? In other departments? If so, can procedures be integrated?

9 Is there any part of the document which is ignored? Are unnecessary facts recorded? Are additional facts needed? Are the correct number of copies prepared?

10 Is exception reporting feasible? Do current reports clearly point out exceptions?

11 Are additional documents needed? What additional documents? Is computer processing required? Are packaged programs available which will meet the needs of the business?

12 Is system capacity adequate? Do bottlenecks exist? Is overtime required? What can be done to eliminate peak loads?

13 Is customer service adequate? What improvements can be made?

ERSONNEL AND ORGANIZATIONAL CONSIDERATIONS

14 Are documents being prepared in the proper departments? By the right people? Could departments be combined? Could any work units be eliminated? What effects would organization change have on personnel?

15 What effect will procedural change have on personnel? Are personnel agreeable to such change? What has been done to reduce resistance to change? What will be done with workers whose jobs are eliminated or changed? If new jobs are created, has proper consideration been given to selecting and training workers to staff these vacancies?

CONOMIC CONSIDERATION

16 What will be the cost of processing data with revised current procedures? What will it cost to satisfy company needs by other alternatives? If the cost of using the computer is greater, are intangible benefits available which are worth the extra expense?

dependent upon the ingenuity of the team in arriving at answers which satisfy company needs.

The following tools and techniques may be helpful in analyzing current procedures and in designing alternatives:

1 *Additional design sessions* Operating managers can explain *why* activities are being performed, and they can answer most of the procedural questions presented in Figure 4-3.
2 *Systems flowchart analysis* Flowchart analysis may disclose bottlenecks, unnecessary files may be discovered, and duplications and omissions may be identified. *Decision tables* may be used in conjunction with, or as a substitute for, flowcharts.[12]
3 *Input/output charts.* These charts show the relationship which exists between system inputs and outputs. Input source documents are listed in rows on the left of a chart, while the output reports produced by the system are identified in the chart columns. An "x" is placed at the intersection of a row and column when a particular source document is used in the preparation of a specific report. The input/output or *grid chart* enables the analyst to identify and isolate independent subsystems quickly for further study.
4 *Electronic evaluation of computer alternatives* Only a limited number of alternative system designs can be *manually* evaluated. Fortunately, however, if a computer system appears to be justified, a computer can be given the firm's processing requirements and can then *simulate* the performance of these requirements using cost/performance models of selected computer alternatives. In other words, *a computer is used to evaluate other computer hardware and software configurations.* One leading computer system evaluation tool is SCERT (Systems and Computers Evaluation and Review Technique), a family of computer simulation programs prepared by COMRESS, Inc., a Washington, D.C. consulting organization.[13]

It is assumed at this point that the study team has analyzed the current operations, has prepared a detailed set of written (documented) systems specifications to achieve the study goals, and has settled on the alternatives which it feels will best achieve those goals. *The prepared specifications should include:*

1 *The input requirements* Included in the input specifications should be the source documents to be used, the means of preparing and transmitting those

[12] For a detailed discussion of flowcharts and decision tables, see Donald H. Sanders, *Computers in Business: An Introduction*, McGraw-Hill Book Company, New York, 1968, pp. 187-206.

[13] See "SCERT: A Computer Evaluation Tool" at the end of this chapter.

documents, the frequency of preparation, and the volume figures expected.

2 *The processing specifications* The new procedures must be defined. How the inputs will be used to prepare the desired outputs should be clearly indicated. All files and records to be used and maintained should be identified, frequency of file usage must be known, and processing volumes (both current and expected) associated with the files should be specified.

3 *The output requirements* The output specifications should include the form, content, and frequency of reports. Volume figures are also needed.

4 *Control provisions* The steps to be taken to provide the necessary internal control should be specified.

DECISION MAKING: STUDY TEAM

Computer usage is justified when the tangible and intangible economic benefits to be gained are greater than comparable benefits received from other alternatives. The type and number of alternatives to be considered vary, of course, from one study to another. In many situations, noncomputer options may be preferable; for smaller organizations, the use of a computer center or a timesharing station may be the best choice.[14] But for the remainder of this chapter we shall assume that the team believes that an in-house installation is justified.

Once the decision to concentrate attention on an in-house installation has been made (with the approval of top executives), there are a number of other questions which should be studied by the team members before they present their final recommendations. These questions include:

1 Which computers should be considered? What hardware/software package would best meet company needs? Can consultants help in equipment evaluation and selection?

2 Which hardware/software package offers the greatest return on investment? Can the company afford the investment at this time? Would other investment opportunities available to the firm yield a greater return?

[14] Regardless of which of these options is chosen, the team should be required to present its findings and the economic basis for its recommendations to a top executive or steering committee for the final decision. Its choice might call for consideration of such matters as computing-service evaluation and selection, estimated return on investment, and program preparation and conversion (with timesharing). Thus, portions of the material which follows may be appropriately considered even though an immediate in-house installation is not being contemplated.

3 Have all possible acquisition methods (rent, lease, or buy) been evaluated?
4 Have organizational and personnel aspects received proper consideration? (These topics will not be considered at this time but will be discussed in the next two chapters.)

EQUIPMENT EVALUATION AND SELECTION To select is to choose from a number of more or less suitable alternatives. Evaluation should be based on the ability of several machines to process the detailed set of written systems specifications which have been prepared. With the availability of whole families of computers from different manufacturers, evaluation and selection is, of course, a complicated task. *The following selection approaches have been widely used:*

1 *Single-source approach* This noncompetitive approach merely consists of choosing the hardware/software package from among those available from a selected vendor. Sometimes the vendor participates in the feasibility study and recommends the package. There is a lack of objectivity in this approach; unfortunate results have been produced; but it has often been used in the "selection" of smaller in-house packages.

2 *Competitive-bidding approach* Systems specifications are submitted to vendors with a request that they prepare bids. Included in the bid request may be a requirement that cost and performance figures be prepared for a specified "benchmark" processing run. The vendors select what they believe to be the most appropriate hardware/software packages from their lines and submit proposals. The team then evaluates these proposals and makes a decision. Some of the evaluation factors to be considered are shown in Figure 4-4. Sometimes this bidding approach yields excellent results. But frequently vendors do not prepare the proposals they are capable of making—this is especially true when a vendor representative feels that his chance of receiving the order is marginal or if the order itself is likely to be small. Other possible shortcomings in bidding include the facts that (1) systems specifications may be altered to improve procedures or, perhaps, to place the vendor's package in the best possible light (the study team must then compare bids based on different specifications—a most difficult comparison indeed, as the vendors well know); and (2) program running (or throughput) times may be underestimated in the bids because inadequate allowance is made for housekeeping and set-up times.[15]

[15]Throughput-time estimates are also subject to complicating variations caused by differences in software and programmer efficiency. Of course, shorter program running-time estimates give the impression of economy in the bids, but such estimates can also lead to the acquisition of hardware with inadequate capability to meet expanding needs.

FIGURE 4-4 EQUIPMENT SELECTION FACTORS

A ECONOMIC FACTORS

1 Cost comparisons
2 Return on investment
3 Acquisition methods

B HARDWARE FACTORS

1 Hardware performance, capacity, and price
2 Presence or absence of modularity
3 Number and accessibility of back-up facilities
4 Firmness of delivery date
5 Effective remaining life of proposed hardware

C SOFTWARE FACTORS

1 Programming languages available (not promised)
2 Efficiency of available software
3 Availability of useful packaged programs, program libraries, and user groups
4 Firmness of delivery date on promised software

D SERVICE FACTORS

1 Facilities provided by manufacturer for checking new programs
2 Training facilities offered and the quality of training provided
3 Programming assistance and conversion assistance offered
4 Maintenance terms and quality

E REPUTATION OF MANUFACTURER

1 Financial stability
2 Record of keeping promises

3 *Consultant-evaluation approach* Qualified data-processing consultants can assist businesses in selecting the hardware/software package. Consultants can bring specialized knowledge and experience and an objective point of view to bear on the evaluation and selection problem.

4 *Simulation approach* We have already discussed the use of such simulation programs as SCERT for evaluation purposes. The SCERT programs are capable of comparing the input, output, and computing times required to process specific applications on all available commercial computers made in this country. The General Services Administration, a housekeeping agency of the federal government, has used SCERT to help in the selection of 10 large-scale computer systems for its regional offices. Simulation provides fast, accurate, and objective evaluation. However, as might be expected in view of the benefits obtained, the use of proprietary simulation models is not inexpensive.

Regardless of the approach used, the study team must compare the quantitative and qualitative factors listed in Figure 4-4 to further limit the choices. At this point (or perhaps at an earlier point) a return-on-investment analysis should be made for economic justification and analysis purposes.

ESTIMATED RETURN ON INVESTMENT[16] The costs associated with the options remaining should be compared with the cost of improved current methods of performing the work. Let us assume that as a result of one cost comparison it is expected that there will be negative effects on after-tax earnings for the first three years, but that after this initial period substantial positive returns are anticipated. It is known that top executives believe that the computer should yield a satisfactory return over a six-year period or it should not, at least for the time being, be acquired. Since the company can earn a 10 percent return on investments made in plant and equipment, it is also the feeling of top managers that the computer investment should be postponed if it cannot produce a similar return.

Armed with this information, the study team prepares the following table:

Year	*1 Effects on cash flow of acquisition*	*2 10% discount factors**	*3 Present value of cash flow*
1	$-100,000	0.9091	$-90,910
2	− 75,000	0.8264	−61,980
3	− 25,000	0.7513	−18,782
4	+ 50,000	0.6830	+34,150
5	+100,000	0.6209	+62,090
6	+150,000	0.5645	+85,675
		Total	$+10,243

*From Billy E. Goetz, *Quantitative Methods: A Survey and Guide for Managers*, McGraw-Hill Book Company, New York, 1965, p. 526, Table 8a.

Column 1, the effects on cash flow, represents the economic effects expected by the team if updated current procedures are replaced by a selected computer system. In other words, this column shows the expected effects of the acquisition on net income plus depreciation. Column 2 shows the *present value* of $1 received in years 1, 2, 3, etc., when the required rate of return is 10 percent. At the end of one year, 10 percent interest on $0.9091 is $0.0909. Thus, the present value ($0.9091) plus the interest ($0.0909) gives $1 at the end of a year. Column 3 is the product of column 1 multiplied by column 2. The

[16] For further details on the subject of capital-investment analysis and the concept of the time-adjusted return on investment, see Chap. 19 of Robert N. Anthony, *Management Accounting*, 3d. ed., Richard D. Irwin, Inc., Homewood, Ill., 1964.

time-adjusted return on investment is exactly 10 percent if the total of column 3 is zero. A negative total means that the 10 percent return cannot be expected. In our example, the estimated return is found to *exceed* 10 percent.

Before leaving the subject of return on investment, it is appropriate to note that 20 of 33 "outstandingly successful" manufacturing companies studied by the consulting firm of Booz, Allen & Hamilton make use of formal return-on-investment analyses in their computer decisions.[17]

ACQUISITION METHODS[18] It is the job of the study team to evaluate acquisition methods and recommend the one best suited to the company. *Computers may be acquired in the following ways:*

1 *Renting* Hardware in about three-fourths of the computer installations is rented from the computer manufacturer. This is a flexible method which does not require a large initial investment. It is also the most expensive method if the equipment meets company needs for four or five years or longer.

2 *Purchasing* Although the rental method is the most popular, there is evidence of a trend toward greater equipment purchasing. This is especially true of the federal government which has, in recent years, substantially reduced the percentage of rented installations. Greater interest in purchasing is due to (1) the fact that it is the least expensive method when hardware is kept for several years, (2) the greater reliability, longer physical life, and greater expected residual value of third-generation hardware, and (3) the belief of some managers that the risk of becoming "locked-in" to a particular configuration is reduced by their ability to do a better job of long-range systems planning.

3 *Leasing* Under the typical leasing arrangement, the user tells the leasing company what equipment is desired. The leasing organization arranges for the purchase of the equipment and then leases it to the user for a long-term period (usually three to five years). This method combines some of the advantages of both renting and purchasing.

Figure 4-5 summarizes the advantages and disadvantages of each acquisition method. The study team should weigh these merits and faults carefully before making its choice.

PRESENTATION OF RECOMMENDATIONS

Guided by a written charter which defined the scope and direction of their efforts, the study team has analyzed the relevant facts; from this analysis has come a detailed set of systems specifications designed to achieve the study goals.

[17]See James W. Taylor and Neal J. Dean, "Managing to Manage the Computer," *Harvard Business Review*, vol. 44, p. 107, September-October, 1966.

[18]For further details on this subject, see Irving I. Solomon and Laurence O. Weingart, *Management Uses of the Computer*, Harper & Row, Publishers, Incorporated, New York, 1966, pp. 187-198.

FIGURE 4-5 EQUIPMENT ACQUISITION FACTORS

RENTAL

Advantages

1 No large purchase price required.
2 Risk of technological obsolescence reduced.
3 Maintenance included in rental charges.
4 Agreement may be cancelled without penalty after brief period.
5 Greater flexibility in changing equipment configurations.
6 Possibility of applying some part of rental charges to later purchase.

Disadvantages

1 Most expensive if equipment is used for long period of time.
2 Rental charges remain same throughout life of agreement.
3 Rental charges may increase when monthly usage exceeds a specified number of hours.

LEASE

Advantages

1 Less expensive than rental over life of the lease.
2 No large purchase price required.
3 Maintenance is included in the lease charges.
4 No additional charges when equipment is used beyond a specified number of hours monthly.
5 Lease charges decline after specified period.
6 Possibility of applying part of lease charges toward later purchase.

Disadvantages

1 User contracts for equipment over long time period.
2 Reduced flexibility—user is obligated to pay a contracted charge if lease is terminated prior to end of lease period.

PURCHASE

Advantages

1 Generally least expensive if machine is kept over long time period.
2 No additional charges when equipment is used beyond specified number of hours monthly.
3 Certain tax advantages accrue to the purchaser.

Disadvantages

1 Equipment maintenance not included in the purchase price.
2 Risk of technological obsolescence—of being "locked-in" to a system which does not continue to meet changing company needs.
3 A large initial capital outlay is required.

After careful consideration of alternatives, the team has concluded that a computer installation is justified. Return-on-investment analyses have been made; a particular hardware/software package has been chosen; and the best acquisition method for the company has been agreed upon. The team has made many decisions. But the *final* decisions are made by top-level managers. It is the job of the team to recommend; it is the responsibility of top executives to decide.

The final report of the feasibility-study team should cover the following points:

1 A restatement of study scope and objectives
2 The procedures and operations which will be changed
3 The anticipated effects of such changes on organizational structure, physical facilities, and company information
4 The anticipated effects on personnel, and the personnel resources available to implement the change
5 The hardware/software package chosen, the reasons for the choice, and the alternatives considered
6 The economic effects of the change, including cost comparisons, adequacy of return on investment, and analysis of acquisition methods
7 A summary of the problems anticipated in the changeover
8 A summary of the benefits to be obtained from the change

FINAL DECISION MAKING: TOP MANAGERS

Top executives must evaluate the recommendations made by the team to detect any evidence of bias[19] and to decide whether the benefits outweigh the disadvantages. Suspicion of bias or of an inadequate effort may be justified if the points outlined above are not included in the recommendation. For example, suspicion is probably warranted if little or no mention is made of the personnel or organizational aspects of the change, if the alternatives considered are really just "straw men" which are obviously inadequate, or if feasibility depends on vaguely defined, intangible benefits.

FOLLOW-UP ON DECISION

If the decision is to accept the recommendations of the team, the top executive should follow up this decision by establishing subsequent project performance controls. Personnel must be selected to do the work; an implementation schedule should be drawn up (using, perhaps, PERT or CPM); and periodic

[19] After all, if the change is made, some members of the study team may expect to move into positions of greater influence.

reports on installation progress should be required.[20] Efforts should be made to meet the anticipated problems—e.g., steps should be taken to reduce employee resistance to the change. In the following section we shall look at some of the technical conversion questions which will have to be considered; in following chapters we shall examine organizational and personnel problems which will have to be dealt with.

Once the computer has been installed and is in operation, a thorough appraisal should be made[21] to answer the following questions:

1 Are procedures being followed? Are all new procedures being processed on the computer? Have old procedures been eliminated? If not, why not?
2 Are any modifications or refinements indicated as a result of operating experience? If so, are they being made? How are they being controlled?
3 How do operating results compare with original goals and expectations? Are economic benefits being obtained? If variations exist, what is the cause? What can be done to achieve expected results.

If the decision is *not* to acquire a computer, a follow-up on this decision may also be needed. Rising labor costs, reduced computing costs, and other factors may make the use of a computer more attractive in a very short period of time. To the "no" decision perhaps should be added, "not yet."

SYSTEMS CONVERSION

Once a decision has been made to acquire a computer, the next order of business for top administrators is to deal with those organizational and personnel matters which now take on immediate importance. The organizational location of the computer must be considered; a computer implementation officer must be appointed; and an effort should be made to inform employees of the effects, if any, which the change will have on their jobs and opportunities.

Depending upon organizational decisions, the computer implementation officer may be a top-level executive, a member of the computer steering committee, and/or a data-processing manager who will be in charge of the emerging computer department. He must be given the authority to plan, organize, staff, and control the conversion phase of the project. His first duties will be (1) to review the policies, objectives, and target dates which have been established by top management to control the project; (2) to submit an

[20] The reading entitled "The Information System Audit: A Control Technique for Managers," at the end of this chapter, presents a number of control questions to be considered during the development, implementation, and post-installation phases of the project.

[21] Data-processing personnel should know in advance that such a follow-up will be made.

implementation plan for top-level approval which outlines conversion time and cost elements; and (3) to select the computer personnel needed to carry out the conversion. From this point on the manager will be involved in planning and scheduling the many jobs which must be completed. A multitude of preparation tasks will go on simultaneously—additional workers may be selected; training must take place; programming and systems-analysis standards should be developed; file conversion must be initiated and carried out; programs must be prepared, debugged, and made ready for conversion; and the physical computer site must be readied. The total time needed for these activities varies, of course, but many months are generally required. To illustrate graphically the complexity of computer-systems implementation, Figure 4-6 presents a network-conversion model.[22] The boxes represent activities; solid lines indicate time consumption; broken lines indicate necessary sequence but do not involve time usage; and the heavy lines show the critical path. The activities listed in many of the boxes will be considered in the following paragraphs. Remaining activities are covered in later chapters.

PROGRAM PREPARATION AND CONVERSION

The following overlapping activities are performed during this phase of the project:

1 *Program analysis* The systems specifications defined during the feasibility study must be broken down into the detailed arithmetic and logic operations required to achieve the goals. *Program flowcharts* and/or *decision tables* are generally prepared during this activity.

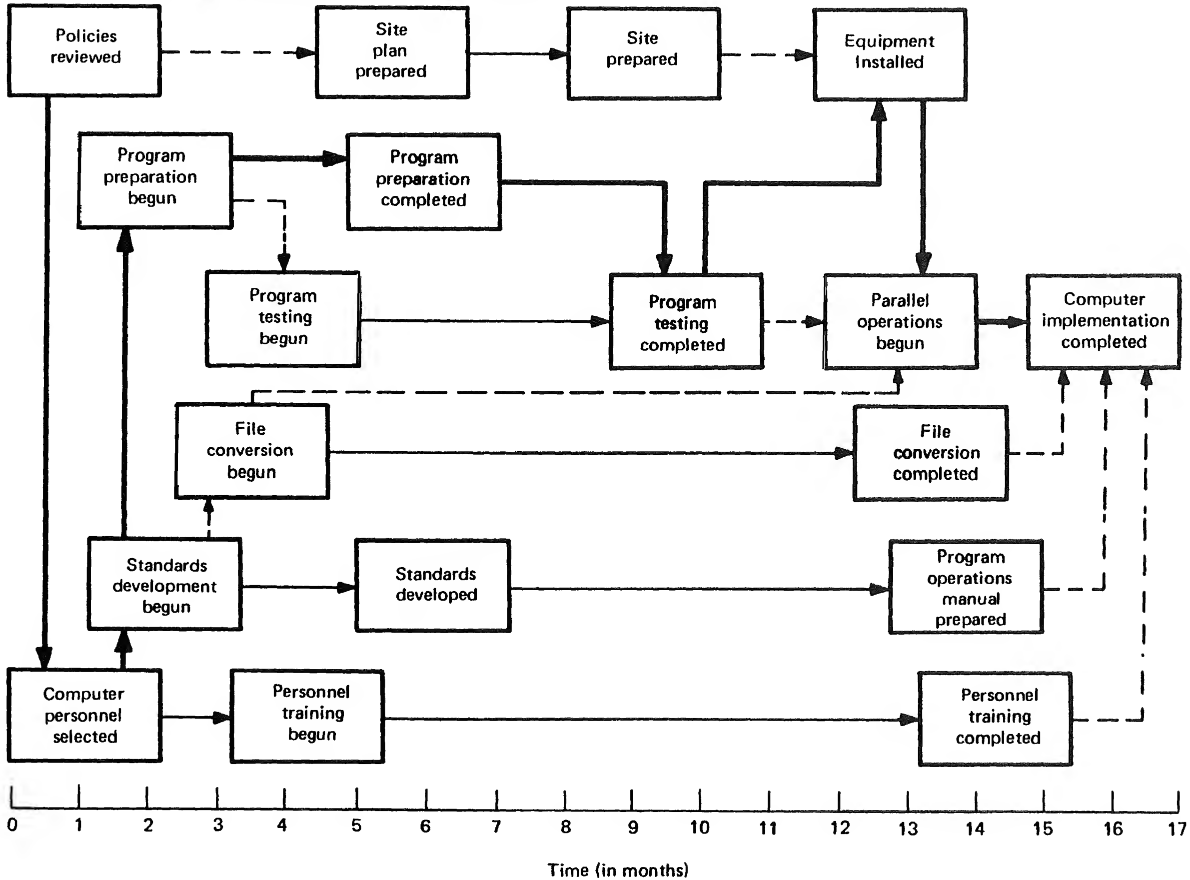
2 *Standards development* Standardized flowcharting symbols should be decided upon and consistently used; standard programming procedures and the use of standardized symbolic names to describe company data should be prescribed.[23] Developed standards promote consistency, reduce future program maintenance problems, and make it easier for others to take over the work of a programmer who decides to leave the company.

3 *Program preparation* Once the necessary arithmetic and logic operations have been identified, they must be translated or coded into a language and form acceptable to the processor which has been ordered.

[22] From David H. Li, *Accounting/Computers/Management Information Systems*, McGraw-Hill Book Company, New York, 1968, p. 155. See Chap. 3, and Philip Blumenthal's article entitled "Network Analysis" in the January, 1968, issue of the *Journal of Accountancy*, for more information on planning and control by means of critical-path scheduling. Detailed network models are helpful in planning and controlling the conversion effort.

[23] The importance of standard data definitions in the development of broader systems has already been mentioned.

FIGURE 4-6 NETWORK MODEL FOR CONVERSION



4 *Testing and debugging* The coded programs must then be tested and errors must be removed (a process inelegantly referred to as "debugging") before the programmed procedures can be considered ready for use.

5 *File conversion* Current files must be changed into a form acceptable to the processor. This can be a tremendous task, and it is one which is often underestimated. Files should be consolidated and duplicate records eliminated; errors in current files must be detected and removed; and file inconsistencies must be found *before* the changeover rather than later when they can cause system malfunctions. Also, new manual methods which are to be developed and new forms which are to be designed must receive attention.

6 *Changeover* When the computer arrives, there should be a shakedown period during which applications are processed by both currently used and new procedures as a final check before the cut-over to the new system occurs. A *parallel running* check involves the processing of *current* input data by old and new methods. If a significant difference appears, the cause must be located. A *pilot testing* approach is sometimes substituted for parallel running. Input data for a *previous* month's operations are processed using new methods and the results are compared with the results obtained from existing operations. Preliminary pilot tests can be run on the vendor's equipment prior to delivery of the user's hardware. Thus, testing and debugging is facilitated through the use of actual input data, and it may be possible to reduce the time (and costs) associated with maintaining two different systems at a later date. Regardless of the checking approach, final conversion to computer production runs come from satisfactory performance during this shakedown period.

The activities associated with the program preparation and conversion phase may represent 50 percent or more of the total human effort expended from the inception of the feasibility study to conversion completion. Because of the time and complexities involved, this phase must begin as promptly as possible. You will recall that earlier in the chapter it was estimated that installation schedules are not met 90 percent of the time. Difficulties with program preparation and debugging almost always contribute to slipped schedules. Good management can help to avoid schedule slippage. For example, by incorporating *application-program packages* whenever possible, the project manager may help speed up the program-preparation activity. It is during this activity, too, that many firms have made valuable use of the specialized knowledge and experience of *software consulting organizations.* Finally, the manager should, in the interests of programming schedule and cost control, establish a formal procedure to evaluate systems change requests occurring after a "freeze point" has been reached.

If program-preparation schedules begin to slip, there is a tendency to slight programming documentation. *Documentation* involves collecting, organizing, storing, and otherwise maintaining a complete written record of programs and the other business documents associated with the firm's data-processing systems. Careful documentation, according to prescribed standards, *is required* during the

performance of *all* activities associated with program preparation and conversion for the following reasons:

1 Documented knowledge belongs to an organization and does not disappear with the departure of a programmer.
2 Work that has been completed will not have to be duplicated in the future if project elements are postponed.
3 Future debugging and program modification will be facilitated because the programmer can obtain a quicker grasp of what was originally done.
4 When staff changes occur, proper documentation serves a training function by helping new employees understand existing programs.
5 Proper documentation will aid greatly in future program conversion when new hardware/software packages are acquired.
6 Poor documentation represents a fundamental weakness in internal control and is an indication of poor management.

To summarize, time made up at the expense of good documentation is likely to be a very temporary gain; it will be lost at high cost in a later period when programs must be tested and when program corrections and changes must be made.

The conversion time is almost always a period of personnel and organizational strain. Data-processing employees may work long hours and be subjected to pressure to complete the conversion. Unforeseen problems, last-minute corrections, and the disruption of data-processing services to using departments, customers, suppliers, etc., may contribute to these pressures. It is at this time that cooperation between data-processing specialists and personnel of affected departments is badly needed. Yet it is precisely at this time that cooperation frequently breaks down because of managerial preoccupation with technical conversion matters at the expense of proper personnel preparations.

SITE PREPARATION

The cost of site preparation can range from a modest figure to hundreds of thousands of dollars, depending on the wishes of top executives and on the extent of remodeling or construction required. *The following factors must be considered during site planning and preparation:*

1 *Location* From an economic standpoint, the computer location should probably be chosen for its accessibility to those company departments which will be closely associated with computer operations. But factors other than economics are often given top priority. Company executives may want a "showcase" installation enclosed in glass, expensively furnished, and located where it can be seen by large numbers of people. Location planning must take into account a structure's ability to support the weight of the hardware. Also, soundproofing will probably be required to control internal and external noise levels.

2 *Space and layout* The physical dimensions of the equipment to be housed; the location and length of power and connecting cables; the space needed to allow service access to this hardware; the data-movement patterns; the storage room needed for input/output media, supplies, spare parts, and maintenance equipment; and the number and size of work areas, offices, and conference rooms—all these factors must be considered in determining the space requirements and the layout of the site. Future expansion needs should also be taken into account.

3 *Air conditioning* Earlier computers needed large amounts of air conditioning to dissipate the heat generated by vacuum tubes. Although heat generation has been significantly reduced through the use of solid state components, air conditioning is still needed for employee productivity and for dust, temperature, and humidity control.

4 *Power and lighting* Hardware electrical requirements must be met. If rewiring is called for (and it is usually needed), the job should be done by qualified electricians in accordance with building codes and fire-insurance rules. Adequate illumination of the site is a detail which should not be overlooked.

5 *Cable protection* Numerous cables interconnect hardware units and supply electrical power. Yet attractive sites have no unsightly cables lying around on the floor to impair safety. The usual practice is to install a raised or false floor and then run the cables beneath this floor.

6 *Fire protection* Since much of the data stored on cards and tapes may be irreplaceable, fireproof materials should be used wherever possible in the site preparation. Hardware and media fire-insurance protection is available. A fireproof vault to store vital records, programs, etc., might be a wise investment. Adequate fire-alarm facilities and emergency power cutoffs should be provided, but a sprinkler system is generally not recommended because of the water damage to media and electrical equipment which might result from its use.

VENDOR ASSISTANCE

The computer manufacturer stands ready to provide a number of services of a technical nature to help the customer make the transition to computer usage. *The following kinds of assistance are commonly offered:*

1 *Training* The vendor provides introductory training for the selected programmer candidates. Included in this training are details about the specific processor model ordered and about the programming languages which will be employed. Brief executive seminars may also be held to acquaint managers with a few of the basic computer concepts. The subject of training will be considered further in Chapter 6.

2 *Program preparation* The vendor may assign a site representative to help with program preparation. This representative knows the computer, he knows how to program it, and he can furnish on-the-job training to the user's programmers. If the customer is important enough, more extensive programming

help may be obtained. But it is risky to place too much reliance on the site representative because company personnel may then not be adequately prepared to take over program preparation and maintenance when he leaves. Of course, the competency of site representatives varies. And even the best ones may not know much about the user's business.

3 *Programming aids* Program preparation is aided by the software which the vendor can furnish. The availability and efficiency of subroutines, packaged programs, operating systems, compilers, etc., are important considerations.

4 *Testing and debugging* Most vendors make free testing and debugging time available (the amount varies) on equipment similar to the user's hardware prior to its arrival time. The site representative, of course, is also available to help with the predelivery testing and debugging of prepared programs. A larger amount of free machine time may be furnished for these purposes after the hardware is installed.

5 *Site preparation and installation* Vendors are of considerable help in site preparation. They have had extensive experience in this matter, and in this case their interests and the interests of the customer are usually the same. Both are interested in efficiency, safety, ease of maintenance, and attractiveness. Vendor engineers, of course, install the hardware and make the necessary tests to be sure it is operating properly before it is turned over to the user.

CONSULTANT ASSISTANCE

We have seen that during the feasibility-study stage consultants can often be used to advantage by alert managers to assist in such areas as systems design and hardware/software selection. Between the feasibility and systems conversion stages, they can offer sound advice on personnel and organizational matters associated with the forthcoming changes. And we have seen that packaged application programs, available from software consulting organizations, may be used during the implementation stage to shorten the disruptive conversion period. In addition, consultants are frequently retained during the conversion stage because (1) the firm's computer staff is too small to finish the mammoth transition job on time; (2) the firm's staff lacks the necessary training, knowledge, and experience to complete the job satisfactorily without some type of assistance; (3) consulting organizations can provide needed training in systems analysis and programming (and they can recommend and incorporate the use of data-processing standards and controls into such training); and (4) it is judged to be more economical to "farm out" certain activities than to attempt to complete them internally.

DISCUSSION QUESTIONS

1 **(a)** What is a feasibility study?

(b) Why are feasibility studies essential?

(c) What are some of the common pitfalls which may be avoided by conducting a proper feasibility study?

(d) What benefits may be obtained from feasibility studies?

2 Identify and briefly explain the steps in the feasibility-study approach.

3 What are the prerequisite principles which should be observed in preparing a feasibility study?

4 What objectives are commonly sought from computer usage?

5 (a) What is a design session?

(b) An iterative process?

(c) Why is a written charter needed by the study team?

6 (a) What questions should be answered during the fact-finding stage of the feasibility study?

(b) During the analysis and design stage?

7 (a) What tools and techniques are useful during the data-gathering stage?

(b) During the analysis and design stage?

8 (a) Discuss the equipment selection approaches which may be employed.

(b) What factors should be considered in equipment selection?

9 Why should a return-on-investment analysis be made during the feasibility study?

10 (a) Discuss the possible computer acquisition methods.

(b) What are the advantages and disadvantages of each method?

11 What technical preparation matters must be considered before the arrival of the computer?

12 Identify and explain the activities which are performed during the program preparation and conversion phase of the project.

13 Distinguish between parallel running and pilot testing.

14 Why is proper documentation necessary?

15 What factors must be considered during site planning and preparation?

16 (a) How may the computer vendor assist the customer during systems conversion?

(b) How may consultants be of assistance?

CHAPTER FOUR READINGS

INTRODUCTION TO READINGS 16 THROUGH 19

16 Guidelines for overcoming some typical pitfalls and problems in the development of new information systems are presented in this reading by Dr. Robert J. Mockler. Problems which may arise because of failure to adhere to the important study prerequisites outlined in the text are revealed. The possible impact of systems changes on organizational structure is discussed.

17 Top executives can keep informed of the progress being made (and the problems being encountered) by the systems-development team by establishing a systems-audit group. Information obtained by the auditors enables top managers to control the development of new systems through the planning, design, conversion, and post-installation phases. Benjamin Conway's article deals with the subject of the systems audit; it also presents a number of questions which should be considered by systems planners and designers as well as by systems auditors.

18 Richard G. Canning's excellent article presents the main steps in systems analysis and design. In addition, consideration is given to (1) organizing the systems project, (2) controlling the progress and costs of the systems effort, (3) the importance of establishing a systems-design freeze point, and (4) the importance of good systems documentation.

19 A description of SCERT, a leading computer system evaluation tool, is presented in this reading by Donald J. Herman. As the text pointed out, SCERT programs compare the input, output, and computing times required to process specific applications on different hardware configurations.

READING 16 DEVELOPING A NEW INFORMATION AND CONTROL SYSTEM*

ROBERT J. MOCKLER

The purpose of this article is to explore some of the common problems encountered in developing information systems and to present some solutions to these problems.

*Reprinted from *Michigan Business Review*, vol. 20, no. 2, pp. 13-19, March, 1968. Reprinted by permission from the University of Michigan, Ann Arbor, Michigan. Dr. Mockler holds a Ph.D. from Columbia and has contributed to a number of publications.

During the past few years the author has worked with a number of companies in developing information systems for planning, control and operations. All of the companies were of moderate size, over $50,000,000 in annual sales. In each case a large portion of the business was done through direct-response selling—that is, selling a product or service through an ad or mailing piece which asks the customer to write the company directly to order the item advertised. The products these companies sold through direct-response advertising ranged from magazine subscriptions and book club memberships to phonographs and television sets.

As they grew, each of these companies saw the need to convert to a computer information system. For all of them the conversion was a difficult task. Because there were many similarities in the problems encountered in developing the systems and in the ways these problems were overcome at each of these companies, it seemed that others might benefit from a review of the lessons learned about identifying and overcoming these problems.

THE DECISION TO DEVELOP A NEW SYSTEM

In each company development of the new system began the same way: management decided to install a new computer to process orders, to maintain the file of customer names for billing and repromotion, and to generate planning and control reports. In all instances the customer names were being maintained on punch cards, but the lists were growing so fast that the card systems were becoming inefficient and uneconomical.

In no case was there a formal feasibility or cost study which compared the old and new systems, cards versus tape, and which determined how much time and expense would be involved in developing the new system. At first this may seem puzzling, since many authorities recommend such studies.[1] Most companies, however, are slow to adapt management theory to practice, and the situation encountered at the mail-order companies studied is probably more the rule than the exception.

Formal feasibility studies were not conducted because each company seemed to have made an instinctive commitment to a new system. As a result, the mission of the systems managers was to develop a new system and perform the conversion as economically as possible, not to determine whether or not the new system should be installed or what would be involved in the development and conversion phases.

[1] See, for example, James W. Greenwood, Jr., *EDP: The Feasibility Study—Analysis and Improvements of Data Processing* ("Systems Education Monograph, No. 4;" Systems and Procedures Association, 1962), and Thomas Hindelang, "EDP Feasibility Study—An Indispensable Prerequisite for EDP Success," *Computer Applications Service, V*, 1965, pp. 36-41.

The first problem common to all these companies, therefore, was the lack of a preparatory or feasibility study. Fortunately, in all instances the economy and efficiency of an updated, high-speed, computerized processing system proved very beneficial to operations.

PREPARING FOR THE SYSTEMS STUDY

The actual systems development studies were begun in the traditional way. A group from the systems analysis section was appointed to do an exploratory study, develop a systems proposal, and prepare programs for the new computer. Then all operations affected by the new information system were notified that the study had been undertaken.

Corporate management gave verbal support to the project, but did not appoint a corporate officer to head the study group and, in fact, attended very few of the group's meetings during the year or so spent developing the new information systems.

The second problem, therefore, was the lack of top management guidance, support and, most important, participation in the systems development study.

THE CHANGING SCOPE OF THE INITIAL STUDY

Because no feasibility study was done, the exact scope of the systems development study and the time and effort needed to develop a new information and control system were not clearly spelled out from the beginning. In retrospect it seemed that management thought of the project as writing a program for a new computer. Only as the systems development group delved deeper into their study did the scope of the undertaking expand into a true information systems study, which was what management finally determined they really needed and wanted.

Through the study group's efforts management came to realize that no judgment about where a computer can be used effectively and economically is possible until the decision-making processes within the company and the flow of information needed for decision making are studied and defined. The computer can be a great aid in decision-making, but it is only one link in the decision-making processes within a company.

Because no one had expected the project to be so complex, it had to be modified as it progressed. The confusion, resistance and waste of time and money this caused could have been avoided by defining the mission broadly, not narrowly, at the outset. Then management could have either provided the time, people and money needed to do a complete project, or lowered their sights and settled for a system of more limited scope.

The third problem, therefore, was not understanding that a total information system was needed, not realizing what such a study entailed, and not providing the resources needed to complete the study.

THE INITIAL PHASE OF THE STUDY

Because at the outset the project was narrowly defined as a computer program writing project, the systems study group first examined each of the individual operations being computerized. As the work progressed, however, the group found they needed to do more background work before they could understand these operations, and they began exploring in more depth such areas as:

1 The general nature of the business and the markets within which the company operated.
2 The company's entire business process, from order receipt to customer payment.
3 The kind of information needed for decision making at the various critical points in the business process.
4 The timing and format of the information needs.[2]

The businesses being studied were mail-order selling operations. Sales or inquiries were solicited by mailings, by magazine or newspaper coupon ads, or by radio and television commercials asking for customer orders. The products sold ranged from $500 television sets to $2 gift merchandise and magazine subscriptions. Sales were solicited from former customers, from the general consumer market, and from customers served by other divisions of the company. Most sales were on credit. The companies were, therefore, retailers, and all of the functions normally handled in the retail store would have to be handled by the new system.

Once the general nature of the business was defined, the systems group looked at the internal business flow. Payments and orders were received in the mail room. Payments were sent to the collection section, which deposited the money and credited payments to customers' orders. Orders were sent to the applications section. If the order was from a customer in good standing, it was processed; if not, it was sent to the credit department for clearance or rejection. Once the cleared orders were processed, products were shipped and customer billing begun. In all, five operating sections were involved.

1 Production or product procurement, including warehousing.
2 Marketing.
3 Accounting and financial analysis.
4 Fulfillment, order processing and file maintenance, including billing.
5 Credit.

[2]These are the steps recommended by Thomas R. Prince, *Information Systems for Management Planning and Control* (Homewood, Illinois: Richard D. Irwin, Inc., 1966), pp. 23-24.

As the systems group extended their study, they found how little they knew about the areas other than order processing and how much they would need to know to develop a sophisticated information system to meet information requirements in all these sections.

The systems study group encountered some problems when they began the necessary detailed study of each of the five areas. Although they had been told to call upon all sections involved in the operation, no one person in each operating section was designated to help the group and no executives from the operating departments were appointed members of the group.[3] Since the systems group was part of the fulfillment (order processing and file maintenance) section, and since they got little assistance from the other four sections, they naturally tended to create an information system designed principally for the fulfillment area, a system which would only secondarily serve the needs of the other sections.

At each company it was necessary for a corporate executive to intervene to resolve the problem. At one of the companies, for example, the marketing manager met with the systems group, saw the inadequacies of the new system, discussed the problem with them, and recommended expanding the study group to include a representative from each operating section. Four operating managers were then appointed to the group, although most of the work was still done by the original study group of systems analysts. A timetable for completion was developed at the same time.

Only at this point, therefore, was the true breadth of the new program officially recognized. What had originally been basically an order processing and file maintenance system now became a total information system, and the group was given the manpower needed to complete the project successfully.

Prior to this step, the scope of the project had been limited, not because management wanted it to be limited, but because they had not provided the mechanism or organization to implement a broader study.

The fourth problem, therefore, was that representatives of each operating section were not made part of the original study group.

DEFINING INFORMATION NEEDS

The next step in developing the information system was to have each operating section define its functions, the kinds of decisions it made, the information needed to make these decisions, and the form in which that information was needed.

[3] The importance of involving operating executives *directly* in the systems study is emphasized by such authorities as John Dearden and F. Warren McFarlan, *Management Information Systems: Text and Cases* (Homewood, Illinois: Richard D. Irwin, Inc., 1966), p. 49.

This was not a simple task. First, the operating managers were reluctant to spend the time required to do this. Each felt that he knew his job and that describing it in a report would be a waste of time. In addition, he felt that he would be reporting to the systems analysts, although he had been told that the system should be serving his needs and thought that the analysts should be reporting to him. Second, a systems analyst needs considerable skill at interviewing in order to draw out information about future or ideal operating needs, for the operating manager tends to speak of the information he now gets, instead of what is required to make good decisions.

Again, the corporate officer closest to the study was forced to intervene. He explained that a periodic review of job objectives and functions was good business, that the systems group really was working for the operational managers, and that the new system was a wonderful opportunity to relieve operational managers of a considerable amount of detail work and to give them better reports, in more readable form. However, the price to be paid over the short run was that each operational manager would be required to devote time to the project. If the managers did not give such time, they could not justifiably complain later of lacking the information needed to make decisions or not having it in the form needed to make decisions quickly.

The fifth problem, therefore, was getting a clear definition of the information needs of each of the decision makers within the system.

BALANCING THE INFORMATION NEEDS OF EACH OPERATING SECTION

Because of the lack of direction from management and support from the operational managers, and because of the systems analysts' training in machine applications, it was difficult for the systems group to maintain a "total information system" perspective and to be objective in balancing the needs of each operational group in the new system.

This point often escapes the systems theorist. Prince, for example, overlooks it in describing the systems analyst's job:

> *The system analyst, like the financial accountant, the financial manager, the sales manager, and the production manager, is concerned with designing observations of certain manifestations of a business organization. But unlike the other cited trained observers, the system analyst does not respond to any traditional set of theories associated with a functional area of the business.*
>
> *The system analyst is concerned with the information dimension of decision-making activities throughout the business organization.*
>
> *The system analyst desires to establish the ideal set of information systems that is compatible with the major decision-making requirements in the existing unique environment of a particular business organization.*[4]

[4]Prince, *Information Systems,* pp. 17 and 19.

While ideally the systems analyst is supposed to have the perspective to view an entire business system objectively and to pull together all aspects of an operation, there is no guarantee that he will. The systems analyst is usually a trained programmer. Because of his background and training he tends to be machine-oriented and to think in terms of the efficiency of machine applications instead of operational decision-making needs. Like the sales manager, production manager and financial manager, then, the systems analyst also has a functional bias.

The ability to view an operation objectively and in its entirety is not an exclusive characteristic of any particular functional area in a corporation. It is a characteristic of effective management. Any good manager, in any functional area, should be able to maintain a broad, comprehensive, objective viewpoint.

In the companies studied, the problem of maintaining a balanced viewpoint was further compounded by the fact that the systems group in a mail-order operation is part of the fulfillment operation. When compromises had to be made, therefore, the group tended to accommodate either machine efficiency or the efficiency of the processing system for the fulfillment area.

As a result, operational managers came to believe that the information needs of their areas—be they product procurement or marketing—were considered secondary to the needs of the fulfillment area. However, these managers were not willing to devote the time needed to help shape the new system to their own needs. The systems group wanted to be objective, but in the absence of sufficient guidance from top management and from the operating managers, they naturally concentrated on fulfilling the needs of the areas they knew best: fulfillment and computer applications.

The situation at this point was chaotic. For example, the marketing section wanted the fulfillment section to make daily manual tabulations of customer orders received by media and to report them daily to the marketing section. This would enable the marketing section to make quicker decisions on the profitability of promotions. The systems group immediately reacted negatively, for the request would require adjustments and delays in their order processing system. In other words, the systems group revealed an unconscious bias towards creating the most efficient fulfillment system possible, even at the expense of efficiency in other operating sections.

The same kind of problem arose when the credit manager asked that certain credit checks be built into the system, when the marketing manager asked that the billing envelopes be enlarged so that he could enclose promotional material in them, when the product procurement manager asked for an on-line perpetual inventory sub-system, and so on.

The situation fortunately did not get out of hand, for in all these cases objectivity was supplied by the informal intervention of a marketing executive, who knew systems, understood the operations affected by the systems, and was well liked by those working on the systems' development. It was this executive

who prevented the systems group from fashioning the system to suit machine efficiency exclusively and arbitrated the compromises necessary to create a system that served needs of all operational areas. It was he who filled the gap left when top management failed to become directly involved in the project.

The sixth problem, therefore, was maintaining objectivity and balance in the new system.

THE FINAL DETERMINATION OF THE COSTS AND PERFORMANCE CHARACTERISTICS OF THE NEW SYSTEM

Not only did management underestimate the costs and complications of developing the system, they also underestimated the costs and performance characteristics of the final system. Fortunately, even though the costs of the final system were higher than anticipated, the savings under the new system were sufficient to justify its installation.

But modifications in the design and size of the new system occasioned sizeable delays. In all cases the computer ordered turned out to be too small. The order was changed, delays resulted, and management had to adjust to increased cost. The configuration also changed and in its final form differed radically from that originally proposed to the manufacturer. Management also had to adjust to some basic changes in the system performance. It was found, for example, that the new system could not substantially decrease order processing time, and that it could only have a modified on-line inventory control.

While some changes are inevitable, a more complete feasibility study would have reduced the number and size of these changes.

The seventh problem, therefore, was making a commitment for a new computer before completing a detailed study of costs and the computer configuration needed for the new system.

THE ORGANIZATIONAL IMPACT OF THE NEW SYSTEM

The systems development program at the companies studied led to major changes in the companies' organization structures. As a result of the project, attention was shifted from what each department had done in the past—that is, which department handled what functions—to the operations and functions that were needed to run this type of business successfully.

Some personnel with narrow viewpoints saw the study as a threat to their positions. And they were right. For the study made it obvious that certain changes in the organization were needed. Other personnel, however, realized that a business is dynamic, and that internal changes are constantly needed to meet changing market conditions and improve operating efficiency. To these persons the new system represented an opportunity, not a threat.

While the adjustments came easily for some, for others, who were not prepared

for the changes and resisted them, the adjustments were painful. Some pockets of bureaucratic resistance were wiped out, for a number of departments were eliminated and their remaining functions were put under existing departments. For the most part this was healthy, but in the process some good people were unfortunately lost. With proper forethought and planning, these people could have been retained.

The eighth problem, therefore, was not anticipating the changes in organization structure and the dislocations in personnel that would be occasioned by the new system, and not developing plans and educating personnel to meet these changes.

OTHER BENEFITS DERIVED FROM THE NEW SYSTEM

A number of other benefits resulted from the new systems in these companies. In addition to a thorough reevaluation of corporate goals and the interaction of the various functional operations needed to achieve these goals, a considerable amount of coordination and education occurred.

A spirit of cooperation gradually developed as operating personnel found that their ideas were needed and used. In turn, the interchange helped to educate operating personnel in the problems of other departments, and in management objectives and policies, both for the coming year and for the longer term.

Such coordination and education benefits did not happen by chance. They came about because in administering the later stages of the system's development management took the time to listen to ideas and follow up on them, and to communicate the nuances of corporate policies and the rationales behind them.

Where deviations from plans or operational deficiencies were found, they were not made a cause for reprimand. Rather, the problems were explored to find their causes, and the ways were developed to prevent their recurrence.

As a result, a well-knit operating group emerged from the systems development program. Operating personnel had a common purpose. They knew what was expected of them, and what the major problems of the business were. They knew that they had the freedom to innovate and make mistakes, and that their suggestions would be considered. Most important, they knew why they were doing what they were doing and how it fit into the rest of the company's operations.

All these side benefits of the systems development project could have been lost, if time and attention had not been devoted to cultivating them.

CONCLUSION

Managers cannot expect everything to go smoothly in developing a new system, but they should not use this as a rationale for tolerating unnecessary

inefficiency. Systems development is a new area, in which most managers lack experience. Clearly, performance in this area can be improved, and this article has attempted to establish some guidelines for improving systems development programs on the basis of the experience of the companies studied. These guidelines may be summarized as follows:

1 Systems development should begin with a feasibility study.
2 A corporate executive should be appointed to head the systems development group, and he should participate actively in the work. Control points should be developed, where top corporate management will also participate in and demonstrate their support of the project.
3 The scope of the project should be defined early, so that management will have realistic expectations for what the systems development program will accomplish and will know how much work will have to be done to fulfill these expectations. Adequate time, money and manpower must be allocated for the project.
4 The study group should include someone from each operating section affected by the new system, to insure the direct involvement of these areas in the project. Deadlines for each stage of the project should be set, to insure the continuing involvement of all parties.
5 Time should be taken to adequately define the major decision-making areas within the business system and of the information needed for effective decision making in each of these areas.
6 Top management should participate directly in the study, to insure that balance and an overall company perspective is maintained in the new system. Extreme care should be taken to see that no one functional area dominates the structure and development of the system.
7 The final commitment for machinery should be withheld until a very precise idea of what is needed has been formed.
8 Major changes in organization structure and major dislocations in personnel will occur, and plans and programs should be developed for making these changes and dislocations as painless as possible. This includes educating everyone concerned in what is happening.
9 Time and effort should be taken to realize the education and coordination side benefits possible from a systems development program.

The companies examined in this study had alert, bright and realistic management. Although there were problems, once they were recognized, management took the necessary steps to resolve them.

These steps could, however, have been taken earlier, thus avoiding many of the problems. Instead of false starts, which made the normal activities required to develop a system seem like problems, each step could have been conceived of positively, as a necessary activity in the normal development of a new information and control system. In this way, there would have been less negative

feeling about the project and fewer hours and dollars lost in carrying out the project.

Hopefully, this study will help others to avoid some of the problems these companies encountered in developing their systems, and will provide a sounder basis on which to build systems development programs.

READING 16 DISCUSSION QUESTIONS

1 (a) Identify eight problems encountered by businesses in developing new information systems.
  (b) What problems identified by Mockler could be attributed to failure to adhere to proper study-prerequisite principles?
2 How might a written charter have prevented some of the problems mentioned?
3 What guidelines can be presented to improve future systems-development performance?

READING 17 THE INFORMATION SYSTEM AUDIT* A CONTROL TECHNIQUE FOR MANAGERS

BENJAMIN CONWAY

More and more companies are turning to information systems to process data in their day-to-day operations and to supply information on which management decisions can be based. At the same time, these systems are becoming increasingly complex and increasingly costly to plan and develop. Because of the size, importance and cost of the effort involved, close management control is needed in the planning, implementation and operational phases of the information system's development. This is particularly true of companies that are widely spread geographically. Such companies often suffer from a proliferation of systems with similar objectives but developed independently of each other.

Management's first concern, of course, must be whether the new information system will meet the company's needs. In determining this, top-level managers must consider not only present needs, but also the needs that will exist when the system goes into operation several years after the planning and development

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work has begun. They also must know what the system will cost, what it will save, what strain it will put on personnel and other resources during its development, and what risks are involved. In addition, they must know if schedules will be met and if the development work is adequately controlled and managed. They also may be interested in what other organizations may be attempting in the same areas.

One way top management can find satisfactory answers to these questions is by performing a continuing audit of the information system from its inception to the time it will go into efficient production. This audit should be conducted by personnel other than those directly concerned with the development and implementation of the system and should be controlled and directed by the top management of the company or its divisions.

Many different functions and activities must be carefully evaluated and controlled if the audit is to help the systems development team place in operation, at the date specified, a necessary, efficient, adequately controlled information system. Therefore the audit itself must be as well planned and controlled as the system under study if it is to cover the necessary ground. The purpose of this article is to describe how the audit should be organized and conducted.

Although the audit has the greatest importance for those companies in which decentralized systems work is involved, it also can be modified to apply to any size or kind of company. It becomes worthwhile when the number of resources to be applied to the development of an information system, or the number of resources that the system will affect and control, becomes significant in relation to the company's total resources.

PLANNING THE AUDIT

The audit team should be kept fairly small to ensure adequate cross-communication and control. It should have one or two permanent members to assure continuity of direction, but in the main should be composed of rotating members able to bring all the necessary skills and technical backgrounds to new problems of control and analysis as they arise. Where the required skills cannot be found within the company, or where the need is felt for a more objective or impartial point of view, members of the audit team should be recruited from sources outside of the company, such as consulting firms or universities.

The objectives of the audit should be fully defined at each of four major stages in the development of the information system. At the planning stage, the audit is more concerned with the business implications of the system, the economics of the system and the controls proposed over its development. During the development stage, the audit is most concerned with the

technical aspects of the program; during implementation, with the adequacy of the conversion procedures; and in the post-installation phase, with the over-all evaluation of the system from operational, efficiency and economic viewpoints.

Assignment of one or more primary responsibilities to individual members of the audit team should be in line with the skills each possesses. However, a member must be able to contribute to the work of other members of the group because none of these responsibilities stands alone but all are interdependent.

Close contact must be maintained with the users of the system so that the audit team members can fully understand their needs and requirements. This applies whether the users are corporate or divisional management, functional staff or direct operational personnel.

A list of questions should be developed by each member of the team in collaboration with users and other team members to explore his responsibility in line with the audit objectives at that time. Where possible; quantitive or qualitative limits should be established so that some form of objective measurement of performance can be attained. Where values cannot be predetermined, the evaluation must be a subjective one. It is important to keep this point in mind when selecting the audit personnel because the personal bias of the auditor must be taken into account when considering his findings.

A timetable should be established for each phase of the audit. The first phase, which is possibly of the greatest importance, should be long enough to achieve its objectives but should be kept as short as possible in elapsed time so that if changes have to be made to the system as a result of the audit, the amount of effort that has been wasted by the system development team is held to a minimum. For this reason the audit team will probably be at its maximum size at this stage. The second stage of the audit, during the development of the system, will take the form of spot checks of various possible problem areas. The third phase, which will take place just prior to conversion, should be long enough to ensure that the conversion problems have been overcome, and short enough to prevent wasted or duplicative effort. The final phase is the evaluation of the completed system. The audit team will look for the reasons behind discrepancies or failures in the system to avoid future errors. This phase should be of relatively short duration.

A reporting procedure to keep systems developers and systems users informed of the status of the audit and its findings is extremely important. The reporting procedure should consist of periodic meetings with documentary support, "immediate action" reports whenever these are necessary and at least one, and possibly more, formal report at the completion of each audit phase.

CONDUCTING THE AUDIT

The audit team must look at the system under review from many different aspects to arrive at an evaluation. Questions that might be asked during any or all of the four stages of the audit are listed below. The list obviously is not all-inclusive. But more detailed and penetrating questions should emerge during the course of the audit.

What are considered satisfactory answers to the questions raised and the topics covered is a matter for each individual company to decide. Each must determine the permissible trade-offs between various alternatives before being able to arrive at a conclusion that the system under review is or is not worthwhile, well managed and controlled, meets the needs of the company and its management, and does not involve the company in unnecessary risks.

THE OVER-ALL NEEDS OF THE COMPANY

1 *At the planning stage.*

The system will take a finite time to develop and implement. Does the system as conceived fit in with the company's long-range plans (assuming that these exist) for this time period? For example, is the volume of business on which the system is predicated in line with the long-range plans? Have future expansions beyond the implementation time frame been considered? Have future problem areas and future objectives been considered in the systems design or plan?

Has the system been considered in the light of over-all company needs? Who has authorized its development, defined its scope? Have company long-range plans been reviewed to determine that even though this system falls within the scope of the long-range plan, there may still be many gaps left for fulfillment of the plan? Should the system scope be widened to cover these gaps, or should separate efforts be undertaken to cover the gaps? Who has given the system the priority that it will be developed in preference to another system; that it will be developed now instead of later?

How has it been determined that this system does not duplicate work done elsewhere in the company? Should the scope of the system be made narrower to avoid possible duplications? Is duplication necessarily bad, or might it lead, through a competitive spirit, to a better final system? If the system is being developed at one location for future use at other locations, have the environmental characteristics of the other locations been considered? Can the system be transplanted easily, or will a major modification to it be necessary?

Have informational or processing requirements been placed upon other organizations or functions of the company for which they have not accepted responsibility? Are these requirements practical, and what steps are being taken to assure that they will be met? Do other organizations or functions

require output from the system? Have these requirements been fully explored? Will input from other functions be compatible with the system's needs? Who have been speaking for these other functions, and do they have the necessary authority to make commitments?

2 *At subsequent stages.*

Has there been any change in the company's long-range plan that has altered the role of the system? Have these changes been effected?

Has there been any change in the relationships with other functions and organizations that necessitate input, processing or output changes in the system? Have these changes been incorporated into the system?

Has a specific responsibility been allocated to a person or persons connected with the system's development and maintenance to continue liaisons to determine when changes occur and their effect upon the system? How does this person plan to fulfill this responsibility?

3 *At conversion.*

Has the conversion been planned in such a way as to minimize the risk to the company if the system fails in whole or in part? Who has the responsibility to determine that the system is no longer experimental or developmental and can be considered safely operational?

4 *Post-Installation.*

Have criteria been established to indicate whether the system is performing well, or whether extra effort is needed to improve parts of it? Who determines that the point of diminishing return in program and design improvement has been reached?

THE NEEDS OF MANAGEMENT

The needs of management closely parallel the needs of the company, but are more concerned with information flow than the scope of the system. And because different people manage in different ways, the requirements of the individual manager must be considered and met in a tailor-made fashion. Furthermore, because functional managers are more concerned with their own informational requirements and do not want to get volumes of largely irrelevant material, the segregation and presentation of information become highly important. The following questions will elicit information to determine how well the needs of managers are being met:

1 *At the planning stage.*

Have all managers who may be interested or should be interested in the system and its outputs been contacted? Have their requirements from the system been fully met in a form compatible with the way they would use it? Have they been consulted about formats or other means of information presentation?

Have managers agreed to commitments placed on them for inputs to the

system, especially the managers of functions and organizations other than those sponsoring the system? What degree of participation did these external managers have in planning the system?

What guarantees do managers have over the integrity of the data? What controls have been applied to ensure the accuracy of both financial and nonfinancial data? What security precautions have been taken to prevent unauthorized personnel from obtaining the data or to prevent unauthorized changes in them?

Does the system provide output of a control nature? Have measurements of past, present and future performance been included so that trends may be spotted and out-of-control conditions observed before they become too damaging? Who determined limits for these conditions? Was he fully authorized to do so?

2 *At other stages.*

Management needs are constantly changing. Is this being recognized? What mechanisms exist to reflect changes? Are these adequate?

Has a continuing relation been established to allow management to evaluate those portions of the system that affect its operations?

FINANCIAL IMPLICATIONS

Financial audits of major systems are not new and the list of questions to be asked and topics to be explored by the audit team are fairly well established. Three points are worth making, however, and these are:

Almost invariably, costs are underestimated.

Almost invariably, savings are overestimated.

Without tight control, even those savings that actually are possible will tend to slip away.

The first two require that the audit team examine costs and savings as realistically and objectively as possible. The third point should be considered when the audit team arrives at the final, evaluative stage of its audit.

RESOURCES COMMITTED

Personnel costs during the system's developmental implementation phases and equipment costs during the implementation and operational phases are the major ingredients of the total system's costs. Therefore the assumptions leading to estimates of personnel and equipment must be closely examined and verified.

1 *Personnel* The tendency in most personnel estimates is to overstate the number of people and to understate the time factor. How then can we determine the number of people who should be involved? There are no good rules for measuring the amount of systems design effort required, the number of program steps to be written, or the amount of systems or programming work that a

person can achieve daily, but there is a vast body of data available for arriving at over-all estimates. Almost any system developed today contains the nucleus of previously performed work. The approach taken and the variations added to a system may be new but they can be compared in complexity with many other systems. Thus, although it is almost impossible to accurately estimate the time required for completion of the work by breaking it down into components, it is possible to arrive at a fairly good over-all estimate by comparison and extrapolation.

In determining if personnel estimates are accurate, the audit team must ask questions like these:

What basic assumptions were made in arriving at the estimates of personnel?

What degree of proficiency of performance is considered as a standard in arriving at these estimates? Can the available resources fit the numerical requirements and the proficiency requirements? If not, what happens to the estimates, and what is the effect on the over-all program?

Was this effort compared with other systems' efforts within the company or outside it, either in whole or in part?

Is there a body of systems work or programming that exists that can be taken over in its entirety or with modifications that will serve the purpose required wholly or in part.

2 *Equipment* Similar considerations apply to the standards used to determine hardware requirements. As with personnel, the tendency is to overstate the requirements, and again if they are overstated, the slack tends to get used up. Perhaps in the case of hardware this is not so important as it is with personnel because useful work usually is performed utilizing the excess capacity. However, this extra work, which can only be justified on the basis of incremental accounting, is not generally of the same priority as other work that could be performed at other places in the company if the cash resources tied up in the excess hardware were free. Therefore, the audit team should carefully examine the assumptions leading to hardware requirements, and should ensure that the possibility of centralizing the work of many physical locations has been carefully considered. Hardware in this context consists not merely of the EDP equipment and its auxiliaries, but also communications networks, terminals and so on, if their use is being proposed.

3 *Skills involved* The skills involved in a complex system include systems analysis, design, programming and operations research. However, equally important to these technical skills is the presence in the design group of the skill consisting of a full knowledge of the user's requirements. It may be possible to design inventory systems, purchasing systems, manufacturing systems, information systems and so on from a theoretical viewpoint, but it is doubtful whether these systems will be able to perform well in practice. Even if they do, many of the user's needs will remain unsatisfied. The audit team must satisfy itself that there has been and will be adequate user participation.

The audit team, in collaboration with the system designers, should attempt to build up a list of the number and kinds of skills required. This skills inventory list can then be checked against the actual skills available. Shortages may affect the scope of the system, or the schedule, and these objectives should be reevaluated in the light of significant skill shortages. Inexperienced personnel, even if they possess the necessary skills or the ability to obtain the skills, may also considerably affect the proposed schedule.

If the effort is subdivided for better control, the subdivisions should be arranged to conform to the skills available. For example, one person with mathematical skills is necessary in the development of a particular system; thus, when the work is subdivided, one subdivision should contain all the problems with which he will have to deal. If this cannot be done, then work in other subdivisions may be held up until he is free. Furthermore, if the subdivisions are being performed at different locations, impossible travel conditions may arise for the specialist. This could lead to excessive costs either in travel or in supplying a second specialist to keep the work going.

CONTROL AND EVALUATION OF SYSTEM

1 *Organization* The first aspect of control concerns the way in which the development group is organized. Especially important when the work is being subdivided among geographically separate groups are questions like these:

- Is there a logical reporting line from bottom to top of the organization?
- Is there a logical chain of command from top to bottom?
- Does the span of control at each location conform with accepted management practices?
- Has the work been subdivided to agree with organizational responsibilities so that major decisions are not left to junior people?
- Is there an adequate responsibility for liaison between the working groups?
- Have the working groups been organized to take advantage of the best skills possessed in the company, or have they been organized by some other criteria; for example, geographically or by function?
- Have the alternative methods of organization been considered?

2 *Subdivision of the work* When the work is being subdivided, the following four points must be considered:

- To avoid duplication of effort, the boundaries of each of the subdivisions must be clearly defined. In doing this, it probably will be necessary to leave gaps between the subdivisions to ensure the completeness and self-containedness of each unit's work. These gaps can be bridged later on.
- To prevent each separate working group from considering its subdivision from its own viewpoint and not from that of the whole system, the work to be performed by each group must be very carefully detailed by the systems

management group. Or a representative of the systems management group must be a member of each of the working groups.

Even though each subdivision should be completely self-contained for development and programming, later on it will have to be fitted back into the over-all system. To do this, standard programming, languages, conventions, field definitions, storage and access methods, and so on are necessary. The question of standards is a very difficult one, but must be tackled in a complex system. Questions should be asked to determine what standards have been applied, especially with regard to the technical aspects given above, and to the definition and format of data arriving from or being sent to external organizations. Where standards cannot be adopted, the questions of how to use the system to perform the translation between one set of data and another must be decided.

The work of bridging the gaps between subdivisions should remain the responsibility of the systems management group to ensure that all necessary interfaces are correctly performed.

3 *Project control and evaluation* The allocation of resources to each subdivision implies a schedule so that subdivisions are completed at the correct time in relationship to each other and to the system as a whole. The schedule should be carefully examined by the audit team to see that it is practical and that there are a series of control points at which individual projects and over-all system progress can be evaluated. This is probably best done through the use of PERT charts or some variation. Plans should exist for the re-allocation of resources as aspects of the work fall behind or go ahead of scheduled dates. Recognition should be quickly possible if the target dates for all or any operational part of the system run into difficulties and cannot be maintained. A formal reporting system to prospective users should be developed so that they are immediately informed of possible delays and can put their own alternative plans into action. Each user should formulate alternative plans for such eventualities.

At the various control points throughout the project, the user—who should be represented in the working group— should have an opportunity to evaluate the project scope to determine that it is still in accordance with his needs as established at the system's inception and as amended by new conditions and new understandings as the work progresses.

4 *Documentation* The system work should be fully documented as it proceeds. Such documentation should not be left until the system is completed because it will fail to represent accurately what has been done. Documentation standards should be established by the system's management group and verified by the audit team. As a minimum, the following documentation should be maintained: system charts, detailed charts, programming detail, change detail in consecutive sequence, test data, results, evaluation, operating instructions and error correction or bypass routines.

The more detailed the documentation, especially in regard to the description of the programming, the more useful it is.

5 *Internal control* The above aspects of control apply to the system's development effort. Some aspects of control also apply to the system itself. Questions need to be asked concerning the accuracy and completeness of input data, processing and output. The audit team should satisfy itself that the system allows for such controls as keypunch verification, record counts for batch operations, input edit routines, hash totals, control totals and so on. Important aspects of control for a real-time, timesharing system concern memory protection, unauthorized or accidental changes of data or programs, and the need for leaving an adequate audit trail. Another control aspect of potentially great importance is that of security of access; that is, the problem of how to prevent unauthorized persons from having access to data that they have no right to see.

6 *Conversion and implementation* The problems of conversion are fairly well known because most companies of any size have already gone through one or more major systems changes involving the conversion process. In addition to seeing to it that adequate solutions are worked out for the problems of converting files from one format to another, conducting testing programs and running parallel operations, the audit must ascertain:

- That there is an adequate procedure developed so that all personnel know what is expected of them during conversion, installation and operation.
- That these procedures are fully documented.
- That procedures for disseminating changes are formalized and that change notifications are promptly delivered to those concerned.
- That these procedures try to cover all possible error or breakdown conditions so that people know what to do when these occur.
- That controls are established to ensure that these procedures are complied with as conversion progresses and as the system becomes operational.
- That measurements of performance in terms of error rates, processing times and so on be established so that systems management can determine the point at which the system becomes operational.
- That an over-all control of personnel be established so that anticipated savings can be achieved by the transfer, if possible, of unnecessary personnel, or by changes in hiring procedures and so on.

RISKS INVOLVED

The audit team must also concern itself with two major kinds of risk:

1 The risk that the system or parts of it will not work. This is especially true when part of the work is experimental. All work of an experimental nature should be identified, and alternative plans should be prepared in case the system does not prove itself. The audit team should verify that plans exist for alternative action if parts of the system fail, or if the system will be subject to significant change or delay.

2 The risk that the amount of resources committed to this particular system may leave other systems' work vulnerable. Questions should be asked about the adequacy of numbers and quality of personnel available to maintain, improve and possibly expand current systems that have to remain in operation. Many companies have found from bitter experience that the work of program maintenance is as important and costly in terms of personnel and equipment as that involved in developing new systems.

I have attempted to outline the requirements for planning and fulfilling an information system audit. In using the audit as a control tool, top management is not usurping the rights or responsibilities of the system's developers. Rather, it is performing its legitimate function of seeing to it that the over-all needs of the company and its managers are met as efficiently as possible.

READING 17 DISCUSSION QUESTIONS

1 What factors should be considered in planning a systems audit?

2 (a) In conducting a systems audit, what questions pertaining to the overall needs of the company should be considered?
  (b) What questions about the needs of management should be raised?

3 (a) Why should auditors evaluate the commitment of resources to newly developing systems?
  (b) What resources are likely to be affected?

4 What questions related to control and systems evaluation should be considered?

READING 18 MANAGEMENT OF SYSTEMS ANALYSIS*

RICHARD G. CANNING

In managing the systems effort, management would like to know in advance, and with reasonable accuracy, *what* will be accomplished and *when* it will be accomplished. In short, management would like to be able to realistically plan the system analysis and design phases of a project and then be able to control progress according to the plan.

In the past, the planning and control of the systems effort has run into difficulties. That is, the job of system analysis often required so much more time than expected that the original plan was useless. One cause of the difficulty has been the mass of detail that potentially can be studied, when studying the

*Reprinted from *EDP Analyzer*, vol. 6, pp. 4-10, July, 1968. Reprinted by permission from Canning Publications, Inc., Vista, Calif. Mr. Canning is a consultant, author of several books in data processing, and the publisher of *EDP Analyzer*.

present system. For instance, we participated in a project some years ago in which some 10,000 man-hours were spent in the data gathering phase alone—and in a relatively small (300 employee) portion of a large corporation. Few guidelines exist for system analysts on what to study and what not to study; if the analyst has a cautious and conservative nature, he wants "more" data about the present system—and sometimes it seems that he can continue to uncover new data until the end of time.

Another reason that actual progress deviates from plan has been that system design turns out to be more difficult than anticipated. That is, the initial designs fall far short of meeting the performance or economic criteria for acceptance, so new designs have to be created and evaluated.

And still another reason for difficulty has been that operating managers many times warm up slowly to the project. Their first reviews of project plans tend to be superficial and they give a "tentative" OK to the plans. (A "wise" manager, if he realizes that he doesn't fully comprehend the new system, always conditions his approval of the system. It gives him something to fall back on later, when he uncovers problems.) Then, as these managers gradually begin to come to grips with the new system and try to visualize how they will operate their departments using it, they begin to see things they would like changed. These requested changes can play havoc with project schedules and costs. Data processing analysts, of course, can't disregard operating management's requests—but we will have more to say about the handling of changes later in this report.

Thus it appears that the systems effort still is not as subject to discipline as is the programming effort. Even so, steps can be taken to reduce the difficulties. To this end, we will discuss the following:

Three main steps in analysis and design
Controlling progress and costs
Project organization
Freezing design and handling changes
Documentation

THREE STEPS IN ANALYSIS AND DESIGN

The three main steps in the analysis and design phase are: studying the present system, analysis of requirements, and design of the new system. We will discuss each briefly, from the standpoint of effective management.

STUDYING THE PRESENT SYSTEM

The dominant characteristic of a study of an existing information svstem is the tremendous amount of detail that *can* be explored. From the standpoint of management, the question is: how much of this detail *should* be explored?

One of the first steps in studying an existing information system is to gather copies of each of the forms and reports currently in use. In saying this, one normally thinks of the "formal" or "official" reports and forms, recognizing that there probably are some "informal" or "unofficial" forms and reports in use. The actual situation may be staggering. We saw figures recently pertaining to the official and unofficial forms and reports in use at three medium size companies. These figures were:

Company	*Official forms*	*Unofficial forms*
Electronics co.	566	1145
Insurance co.	3120	2672
Aircraft co.	2249	2683

In another instance, a division of a major aerospace firm found that data processing was preparing some 1500 different "reports" for the accounting function alone.

While it is likely that the number of unofficial forms and reports could be reduced by careful analysis, consolidation, and elimination, the point to keep in mind is that each one of these was created to meet some particular need. Just searching out and obtaining copies of all the official and unofficial reports and forms is a big job in itself; gaining an understanding of the need for and use of each of these is an even bigger job—and charting the flow of each one of these would be a tremendous job.

What accounts for this large volume of reports and forms? One factor is changing business conditions; as problems arise, forms or reports are created for recording and control so as to deal with the problem in the future. A related factor is the variations that tend to occur between different geographic locations within the same company, or between product lines, or even between different people doing the same job in the same department. Some of the variations are due to personal preference, while others are due to differences in the business environment. For instance, a product line that is in its early stages of development and marketing may need much more detailed reporting for control purposes than does a stable product line that has been established for many years.

How should the systems effort be managed, with respect to the study of the existing information system? The answer to this question is influenced by the degree of participation by the operating managers.

HEAVY PARTICIPATION BY OPERATING MANAGERS If operating managers participate heavily during the analysis and design stages—through what we nave called "design sessions"—much of the formal data gathering tends to be

bypassed. The managers tend to enter immediately into the definition of requirements and then the design of the new system. In the course of this work, if data is needed about the present system, they know who to call and what to ask.

The design sessions that we have participated in have been conducted for periods ranging from several days to several weeks, depending upon the scope and complexity of the system under consideration. In our experience, it was usual for about four to six key operating managers to be selected to attend these sessions full time, plus two or three key representatives of data processing and (perhaps) operations research. Not only should the sessions be full time but they should also be held on continuous working days—because it normally takes a couple of days for the managers to really concentrate on the subject at hand and set aside the problems at their offices. But after their attention has been captured, progress can be quite rapid.

In the design sessions with which we are familiar, the managers normally concentrated on the desired outputs. They frequently came to the sessions armed with copies of all reports and operating documents currently in use, and could answer many questions about those documents. When questions arose which they could not answer, they knew how to get the answers quickly. Frequently other people, knowledgeable in specific areas, would be invited to attend the sessions when their areas were being discussed. The end result was that the system analysts were spared the necessity of gathering much data about the present system.

STUDY PERFORMED PRIMARILY BY SYSTEM ANALYSTS. In those instances where operating managers do not participate heavily in the analysis and design stages, then the system analysts must study the present system so as to determine the requirements for the new system. Here, too, the approach can follow two main courses, depending on whether or not the analysts have a broad familiarity with the company's operations.

If the analysts are quite familiar with the company, the normal approach is for them to immediately become engaged in studying the area under consideration. As we pointed out earlier in this report, the mass of detail that they *could* gather is staggering, so data processing management should see to it that a careful selection is made of what data to gather. We favor the structured approach found in IBM's Study Organization Plan (SOP) for gathering this data. SOP provides procedures for studying the existing forms and reports (messages), files, and operations, without the need to chart the flow of all forms and reports. Experience with SOP has demonstrated that an effective study of the existing system can be made without getting trapped by too much detail.

If the analysts are not familiar with the operation being studied—as is the case with consultants, system engineers from the computer manufacturer, newly hired analysts, etc.—then SOP recommends a brief, broad study of the enterprise. This broad study has a further benefit: if substantial improvements are to be

made by means of improved system design, they must be made in relation to the basic goals of the enterprise. So where big improvements are desired, or where the analysts are unfamiliar with the enterprise, SOP advocates that such information as the following be gathered at the outset: history and background of the enterprise; industry background; business objectives and goals; major policies and practices; pertinent government regulations; business structure (its inputs, outputs, and resources); and projections of markets, products, budgets, and facilities.

Surprisingly, this broad study does not require a lot of time; it has been performed in many medium size companies in four to five man-weeks of time. Once performed, it can be used in conjunction with other system studies. Actually, we think it would be valuable information regardless of the situation—that is, whether design sessions were being held or whether the analysts had a good knowledge of the company.

Following the broad study, SOP calls for gathering the information already described—forms and reports, files, and operations.

ANALYSIS OF REQUIREMENTS

The main reason for studying the existing system is to determine the information requirements that the new system must satisfy. One goal here is to determine what is logically necessary, as opposed to information that is requested "because we have always had it." A related goal is to perform a simplification and streamlining of the information system by attempting to remove unimportant variations or complexities.

The words—"unimportant variations and complexities"—are easy to say and hard to define. People prefer to continue receiving the types of information with which they are familiar and have learned to work—and they may fight vehemently against any changes to what they consider important. For instance, one approach to system simplification has been the consolidation of several reports into one report. In performing this step, it has often been necessary to change the sort sequence from that of some of the prior reports; the operating departments receive the same information but in a different sequence in the new report. And this change may cause many arguments, because some users find the new report less convenient to use.

The new data management systems will help solve the problem of report contents and sort sequences. Reports can be prepared on a demand basis—and if an operating department wants a report in a particular sequence, they should get it in that sequence. The price paid will be in extra computer time but often that is becoming a secondary item of cost. If the new information system will operate under data management software, the analysis step will be primarily concerned more with the contents of the data files than with the exact format of the output reports.

The National Cash Register Company has recently developed a new technique

that appears to be a powerful tool for the analysis step. Called Accurately Defined Systems (ADS), this technique is concerned with identifying the required outputs, inputs, historical data, and processes for the new system. It is basically simple in concept and easy to use; it is equipment independent and can be easily understood by operating managers and personnel. Thus they can review the specifications for the new system and can make necessary changes and corrections. At the same time, the technique gives the system analysts and programmers a clear definition of the system for the purposes of design and programming.

We will have more to say about ADS later in this report. In brief, though, we see IBM's SOP as providing an effective tool for studying the existing information system, and NCR's ADS as providing an effective tool for analyzing the data and defining the requirements for the new system. We see these two techniques as more complementary than competitive, even though proponents of each tend to view them as competitive.

Another aspect of the analysis step is the identification of performance criteria and tradeoffs between performance factors in the new system. It is hard to pin managers down as to what they will deem poor-versus-good performance and the tradeoff between performance factors, but this information will be invaluable to the system designers. As an illustration, the performance criteria for an order entry system might include the following: anything over a four hour order entry cycle is unacceptable; a one hour order entry cycle is reasonable; we would not be willing to pay extra money for an order entry cycle faster than 15 minutes. In connection with tradeoffs, the relative amounts of money that management is willing to pay for the different levels of performance would be stated.

Finally, the analysis step is the time that improved decision-type methods should be selected, if desired. For instance, if improved short range forecasting is desired in an inventory control application, this would be the time to investigate different approaches and select the preferred one. Thus a management science study might be conducted in parallel with the information system study, and timed so that the methods selections are made during the analysis step of the information system study.

SYSTEM DESIGN

The prime goal of the system design stage is to consider alternative designs and select the one that best meets management's needs—best, that is, in relation to the alternatives considered.

The most common approach to this stage has been for the system analysts to conceive and manually evaluate alternative designs. When they find a design that seems to meet the needs, they tend to lock on to that design and attempt to sell it as *the* solution. Because manual evaluation—timing and costing many computer runs, for instance—is so slow and costly, few alternative solutions are

investigated. We feel that this approach always has been a poor one—and in these days of more complex systems, it is becoming less and less tenable.

A better approach is to make use of a mechanized evaluation method, so that many alternative designs can be considered. One such method is SCERT.*

An even better approach, in our opinion, is to obtain heavy participation by operating managers in the analysis and design stages—as discussed above—and then use a mechanized evaluation method for evaluating alternative designs. We should emphasize, of course, that skilled data processing system designers should participate; the operating managers cannot do the job by themselves.

GENERAL PATTERN

Usually these three steps—studying the present system, analysis of requirements, and design of the new system—are performed twice, in most cases with which we are familiar. They are performed once during the feasibility study, in a fairly limited fashion. Then, if the project is approved for implementation, they are performed again in greater depth during the system design phase.

Ideally, of course, it would be desirable to perform these steps in sufficient depth during the feasibility study so that very little repetition would be needed during the subsequent phases. The question, though, is the probability of obtaining approval for project implementation. If there is a good chance of not proceeding with the project, then feasibility study costs should be limited. On the other hand, if the feasibility study is limited, the chance exists that something has been overlooked that will significantly influence performance or costs.

As far as we know, there is no "right" answer to the length of a feasibility study. All that can be said is it is usually not long enough, so time must be spent as effectively as possible. In our opinion, the charting of existing procedures is largely a waste of manpower and should be avoided.

TESTING AND CONVERSION

It is essential that the detailed plans for testing and conversion be developed during the design phase. For testing, this includes a listing of all test cases that will be used, the conditions that each test case will test for, and the dates by which each test should be completed. Conversion plans should include the decision on how conversion will be accomplished (immediate cut-over versus gradual cut-over, for instance), the conversion schedule, and the user training that will be necessary. Brandon Applied Systems, Inc. has been offering a training course on computer systems analysis techniques that discusses these questions in some detail.

*Editor's Note: For information on SCERT, see the reading which follows.

CONTROLLING PROGRESS AND COSTS

As discussed above, most of the effort during the design phase can go into studying the present system, so that plans and controls should be carefully laid out for this step. The best approach with which we are familiar is to break down this study into relatively small segments of work and then estimate the man-hours of time required for each segment. A Gantt chart can be constructed to show the sequence and personnel assignments.

How big is a segment of work? In studies with which we are familiar, a segment has been some logical group of operations. For instance, an accounts receivable application system might be broken down into segments having such names as: opening new accounts, checking credit, posting daily sales, posting cash receipts, billing, making bill adjustments, etc. The man-days required to study segments of this size can usually be estimated with reasonable accuracy. The chance still exists, of course, that a segment will turn out to be far more complex than originally estimated. But during the planning of the studies, conversations with operating managers should pinpoint areas of unusual complexity.

We have seen small PERT charts used effectively in the planning of such studies. Once the segments have been identified and the personnel assignments made, a PERT chart can be laid out. In many instances, a chart of 30 to 50 activities will be adequate and can thus be developed and maintained manually.

A point of critical importance in meeting project schedules and costs: a system design freeze point must be set and enforced. This freeze point should occur at the end of detailed system design. The main effect on the systems effort, of course, is the need to get requirements and specifications crystallized as much as possible during system design, to cut down on the number of mandatory changes after the design freeze point.

Another point to consider is that of expected operating costs of the new system. It is not unusual for changes in system design to be made during the detailed design phase that will increase the eventual operating costs over what was estimated in the feasibility study. In well-managed system efforts that we have observed, the manager does not just accept such increases, but challenges the system designers to find other design changes which will offset the increased costs. A mechanized method for timing runs or jobs would be most desirable, for frequently reassessing the impact of design changes on operating costs.

PROJECT ORGANIZATION

We have just mentioned the importance of effectively freezing the design of the new system at the end of the detailed design phase, if programming schedules and costs are to be controlled. But to make a "design freeze" philosophy work, it is essential that most of the causes of later changes be eliminated or greatly

reduced. One of the major causes of requested changes is that of operating managers who do not begin to grasp the full implications of the new system until they see conversion approaching. So it is most important to achieve meaningful communications between the design staff and the operating managers during the design phase.

How can meaningful communications be achieved between these two groups? A variety of ways have been tried:

An operating manager is made the project manager.

Co-managers are assigned, on a partnership basis, one an operating manager, one from data processing.

Full-time liaison persons are assigned from key operating departments.

System analysts are selected from operating departments.

Operating managers participate in system design via design sessions.

Frequent reviews are held with operating managers during design phase, pointing out implications of the new system.

There is no magic formula for solving this problem of communications. All of the above solutions have worked effectively when used with sincerity and intelligence. None of them will work automatically.

While we have seen excellent results obtained when an appropriate operating manager has been made the project manager, this solution will not be applicable in all cases. In fact, most data processing departments resist this solution, as far as we can tell, and prefer to head up the projects themselves.

Data gathering activities, performed during the study of the present system, can often be assisted by people from the operating departments. In the instance mentioned earlier in this report, where some 10,000 man-hours were expended on the data gathering activities, much help was obtained from the operating departments. About 25 people were assigned in total from these departments; these people were given a short training in the use of the data gathering forms and methods, and their work was reviewed as each segment was completed. This method worked quite effectively.

As a digression, a one-hour session was scheduled twice a week in this study where the various teams would present the results of their studies, with all participants present. It turned out to be an excellent educational process for covering company operations and engendered real interest in the project by the participants.

A new type of specialist will be making his appearance during the design phase of near-future projects. This is the *data specialist,* who will be charged with the responsibility of creating all data definitions, file organizations, and record layouts. No longer will individual programmers lay out records and files pretty much to suit themselves. Instead, a very capable programmer-type, with an aptitude for this work, will perform such activities. The field is finally recognizing the crucial importance of data definitions—for program operating

efficiency, for easing future changes, for compatibility between applications, etc. This function deserves the type of attention that the average programmer cannot provide.

A final point: in order to have operating managers participate more effectively during the design phase, it would be well to give them background training in data processing.

FREEZING DESIGN AND HANDLING CHANGES

As we have pointed out, it is important to institute a system design freeze point at the end of the detailed analysis and design phase if schedules and costs are to be met for the remainder of the project. And, as we discussed last month, a program design freeze point is necessary at the conclusion of the program design phase.

Freezing design means that henceforth any proposed changes must go through a formal submission, evaluation, and implementation procedure. It does *not* mean that no further changes can be made. However, during evaluation the proposed changes are separated into two major categories—mandatory or desirable. If mandatory, the timing is investigated; some might be delayed until the new system is working. If urgent, then the change will have to be made. What design freeze *does* mean is that someone—say, an operating manager—does not informally request a change and a system designer informally agree to make it.

We have discussed one major cause of changes—inadequate communications between the system designers and the operating managers during the detailed design phase. If operating managers really begin to comprehend the new system only after programming has commenced, delays and extra costs are sure to occur.

But there are other causes of changes. Programming is a slow process and it stretches out the implementation cycle. A long implementation cycle means that business conditions can change and the information system may have to be modified to accommodate the changed conditions. The system analysts and programmer may see ways in which the design can be changed to achieve operating economies. And sometimes the need for a change is caused by a clear oversight during the detailed design phase.

We see the new data management systems* as playing an important role in handling changes. Data management systems promise to drastically cut the implementation cycle for new applications. This means, for one thing, that there

*Editor's Note: See Chap. 2 and the readings at the end of that chapter for information on data-management systems.

is less chance for business conditions to change during the shorter implementation cycle. It also means that when a change is necessary or is desired, it often will be made much more easily—because if a data management system helps create the new application system more rapidly, it can help change the new system more rapidly also.

DOCUMENTATION

The conversion to third generation equipment has spotlighted the fact that program documentation too frequently is inadequate. The same can be said of system documentation. Only the minimum documentation may be developed in the eagerness to get on with the more interesting parts of the project.

What does good documentation consist of, for system analysis and design?

1 Charter or work statement for the project, setting out what is to be accomplished, the goals and objectives, what resources will be used, and so on.
2 The project plan and budget, both in original form and in updated form.
3 Data gathering documentation, for each segment of work—including scope and boundary definition of the segment, the file, message, and operation sheets, volume data, etc.
4 The analysis documentation, including ADS documents (if used), any operations research studies leading to new decision rules, and documentation supporting system requirements.
5 Design documentation, including overall system design diagrams, data designs (inputs, outputs, records, file organization), overall program logic, performance criteria, supporting clerical procedures, equipment requirements, and operating time estimates. If alternative designs are being submitted for selection, schedules and budgets for each design should be documented.
6 Testing documentation including identification of all conditions that must be tested, the test cases designed to test those conditions, and the dates when the various tests are expected to be completed.
7 Conversion documentation including the overall plan of conversion, the schedule, user training schedule, and broad plans of action in case serious troubles are encountered.

READING 18 DISCUSSION QUESTIONS

1 Why has the systems-analysis job often taken more time than was originally expected?
2 How can participation by operating managers reduce the time required for formal data gathering?

3 "The main reason for studying the existing system is to determine the information requirements that the new system must satisfy." Discuss this statement.
4 "If the new information system will operate under data-management software, the analysis step will be primarily concerned more with the contents of the data files than with the exact format of the output reports." Why is this statement true?
5 (a) Why is the establishment of a systems-design freeze point an important control technique?
  (b) Does having a freeze point mean that no further changes can be made?
6 What is a "data specialist"?
7 What should be included in systems documentation?

READING 19 SCERT: A COMPUTER EVALUATION TOOL*

DONALD J. HERMAN

With a large and growing selection of third-generation computers now at hand, it becomes increasingly difficult to justify continued use of manual computer management methods. And yet, this is just what is happening. In an industry built around ultra-fast data handling and processing, the science of computer management is being left behind. Example: it often takes months, and sometimes years, to reach final management decisions about sophisticated new systems. This is understandable since requirements must be defined and specifications prepared before proposals can be obtained, evaluated, and final equipment selected. But the end result is still the same—a long time lag.

Or look at some day-to-day computer management problems. How long will it take to program a specific problem? How many programmers are required? How much running time will be involved? What will be the memory requirements? All these questions, plus many others, are still being answered with first generation management methods.

EVALUATION OF HARDWARE/SOFTWARE

But now we are beginning to move into an advanced generation of computer management. With proprietary techniques developed by COMRESS, Inc., the

*Reprinted from *Datamation*, vol. 13, pp. 26-28, February, 1967. Reprinted by permission from F. D. Thompson Publications, Inc., 35 Mason St., Greenwich, Conn. Mr. Herman is president of COMRESS, Inc.

computer manager has a new tool at his disposal—the computer whose talents range from evaluation of other computers to providing accurate flowcharts of programs that may have been patched and repatched without adequate documentation and even to *translating programs* from one computer language to another.[1]

One of these tools, used to assist in making management decisions about computers, is SCERT (Systems and Computers Evaluation and Review Technique), a family of computer programs that is used to simulate the performance of a user's processing requirements against cost/performance models of selected computers. These performance models are built from a constantly updated tape library that contains software and electronic and mechanical hardware characteristics for virtually all available commercial computer equipment.

By using SCERT as a management aid, the director of a computer operation can answer such questions as: Is my present computer equipment utilized efficiently? How can I optimize my computer capacity? What additional operations should I computerize? What effects will changes have on my current system?

For the computer manager who is planning for the acquisition of third-generation equipment, SCERT can help answer questions like these: What is the best processing flow design for my applications? Should I consider on-line, real-time, random access? What complement of equipment is best for my operations? Should I rewrite or emulate our programs? Should I purchase or lease the selected equipment? What programming language should I use?

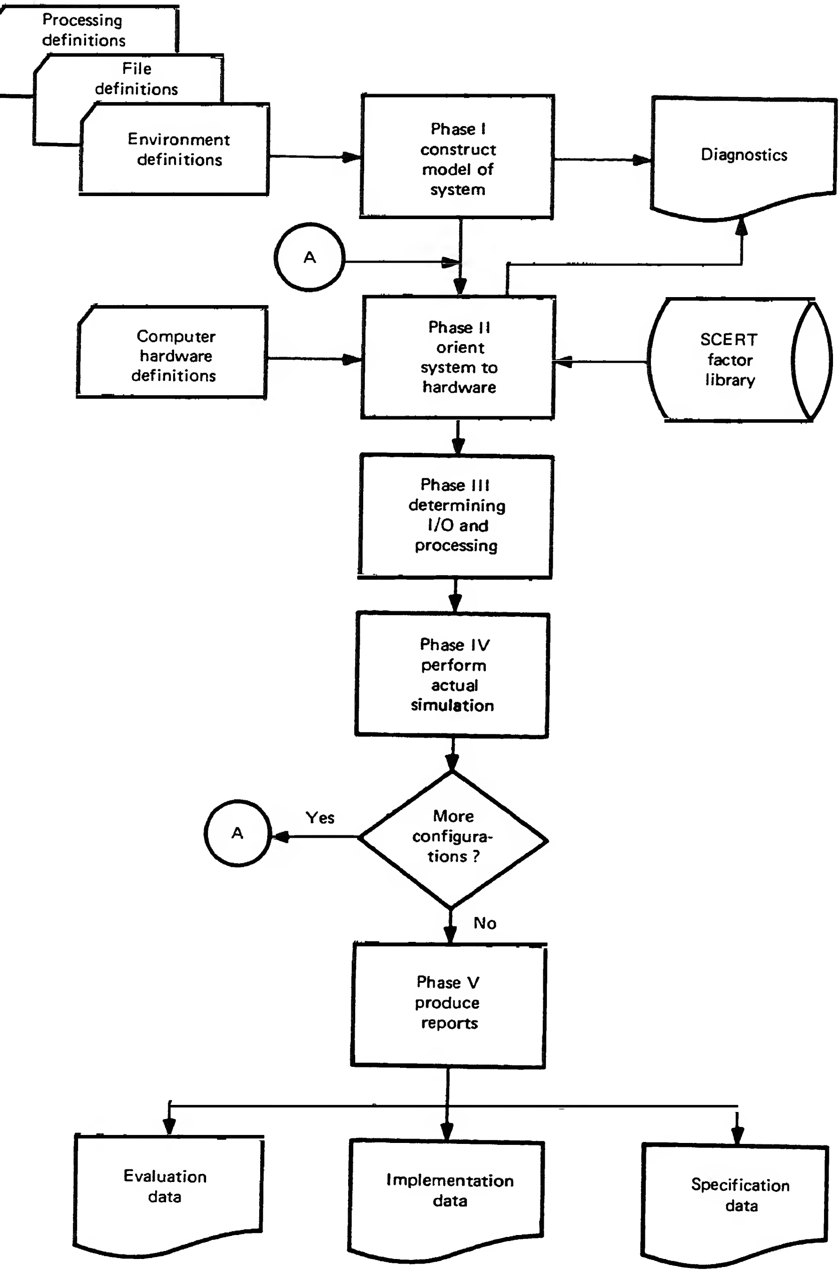
TECHNICAL FEATURES

SCERT is essentially a five-phase program (see Fig. 1). Phase One builds a matrix for each computer run or real-time event in the entire system. These matrices array the variables which describe the unique processing requirements for each individual computer run and are based on the system, environment and file definitions.

System definitions are basically a verbal portrayal of the system chart, reflecting frequency of occurrence, identification of I/O files, and the type of internal computer activity. The file definitions reflect such data as number of records, number of characters per record, number of alpha and numeric fields, and the category and data media of the file. The environmental definitions provide SCERT with the necessary data for all computations involving subjective considerations. For example, they allow for the user to specify the experience

[1]We have satisfactorily proven, in testing the prototype, that the TRANSIM program can accomplish 100% computer-to-computer translation for our selected pairs of machines. The software, however, is not being marketed yet.

IGURE 1



Processing definitions
File definitions
Environment definitions
Phase I construct model of system
Diagnostics
A
Computer hardware definitions
Phase II orient system to hardware
SCERT factor library
Phase III determining I/O and processing
Phase IV perform actual simulation
More configura- tions ?
Yes
A
No
Phase V produce reports
Evaluation data
Implementation data
Specification data

FIGURE 2 PRE-SIMULATION ALGORITHMS

During Phase Three, SCERT computes the following data for each program run or random event:

1 Internal processing time and memory requirements. As a byproduct of these calculations, it also determines the number of program steps required to perform the internal processing.
2 The assignment of all files to available peripheral devices and channels.
3 The structuring of files to the hardware in terms of record format and size, file blocking or batching and provision for alternate areas.
4 Peripheral device timing for all input/output functions and the memory requirements for such functions.
5 The timing of generalized software packages, such as sorting, compilations, IOCS and operating system overneads.
6 Pre- and post-run timing, such as program insertion, set-up time, multi-media change time, error correction time.

level of programming personnel; the salaries for programmer and operators to be used in performance/cost correlations; the life expectancy of the computer, and the corporate cost of money. The environmental definitions are also used to specify the software that is to be included in the simulation, such as what level of operating system will be employed, what programming language is to be used, and what choice will be made of other variable software such as sort and IOCS packages.

During Phase Two, SCERT's library supplies the hardware and software performance factors of the particular computer configurations that have been specified. These factors are arrayed in the form of a three dimensional matrix and then the mathematical models of the runs in the system are oriented to conform to the hardware requirements of each computer to be evaluated.

During Phase Three, numerous pre-simulation algorithms are performed (see Fig. 2). It is this pre-simulation analysis that makes SCERT unique when compared to all other simulation techniques. By performing these calculations, SCERT adjusts the non-hardware-oriented processing requirements developed during Phase One to the particular hardware/software complex specified in Phase Two, so that resimulation of the same processing design on widely differing complements of computer hardware can be accomplished without modification to the basic input definitions.

During Phase Four, the models of the processing requirements are simulated on each computer configuration model specified. Three basic stages of simulation are accomplished. These may be summarized as:

1 A throughput simulation to derive the net running time unique to every computer run and real-time event simulated.
2 An event oriented simulation to combine the various throughputs that may occur simultaneously within an individual real-time event or during batch processing.

FIGURE 3 SCERT OUTPUT REPORT SUMMARY (COMPUTER EVALUATION)

SYSTEMS SPECIFICATIONS A set of flow-charts for each run in the application used to prepare specifications for manufacturers' proposals.

COMPUTER COMPLEMENT Complete identification and specifications of each component in each configuration.

DETAIL PROGRAM RUN ANALYSIS: A three-part report that analyzes each computer run. Part I shows the total buffered and unbuffered time required for the running of each input and output file, the I/O device assignment by SCERT, the data channel to which the file has been assigned, the number of reels, and the optimum records per tape block. Part II analyzes the internal computation including time, memory, and program steps by function. Part III forecasts the time required for program insertion, multi-media change, real-time interrupt, multi-program delay, end-of-job rewind, and the other functions.

CENTRAL PROCESSOR UTILIZATION A summary, by individual run, of the forecasted program operation time and total memory requirements, by day, week, month, quarter, and peak month.

PROGRAMMING REQUIREMENTS A forecast of the number of steps to be programmed and the requirements in man-months for each program run.

APPLICATION SUMMARY A list, by sub-application (payroll, inventory accounting, personnel accounting, etc.) of the processor use by month, set-up time, total programming effort, and programming costs.

COST SUMMARY A two-part report that specifies the cost to install and operate a computer after all applications have been programmed; includes purchase-versus-rental comparison, recurring costs report showing monthly rental based on the projected use of each component, and total personnel salaries for operation and maintenance.

COMPUTER CAPABILITIES An indication of critical hardware areas showing the total time needed to process each run plus the time used by each device in each run.

MULTIPROGRAM RUN SCHEDULE Shows the main run into which potentially parallel runs have been scheduled, based on frequency, priority, and availability of time, core and peripheral devices.

REAL-TIME ANALYSIS A series of reports generated only when real-time processing is involved. The first report analyzes each random event in terms of its unique throughput; the second analyzes every potential queue present in the hardware complex; the third reflects the expected and worst case response times for each real-time event through both the computer complex and the total communications network, and the fourth outlines the memory required for each random event for both the normal and worst case situations.

SCERT SUMMARY A one-line summary for each computer complement after all computers have been evaluated. It reflects the average monthly rental, average monthly use in hours, and a time-and-cost correlation in terms of computer power per dollar. It also lists the number of hours available for expansion and compares the total cost of rental versus the total cost of purchase (less trade-in) for a pre-determined number of months.

3 A time oriented simulation to determine the degree of concurrency and its effect on total throughput available in multiprogramming or multiprocessing environments.

Phase Five provides the user with various levels of data developed during the course of the simulation and evaluation computations. This data is presented in the form of management reports (see Fig. 3), capsuling the information required to make intelligent decisions rapidly.

THE CALIFORNIA EXPERIENCE

Experience with the California Dept. of Motor Vehicles illustrates the time savings that SCERT can offer decision-makers in systems design work. The department decided to build a management information system that would integrate all departmental functions and take advantage of real-time, on-line processing and the use of mass random-access devices for storing information on all state-registered vehicles and drivers' licenses.

One consulting firm advised state officials that at least a year would be required to define the problem and as many as five years might be required to implement the system. Using standard, manual management techniques, the estimate was realistic. Using computer management techniques, however, we were able to define the problem and determine systems feasibility in six weeks. Two weeks later, SCERT-prepared specifications were sent to manufacturers, and their proposals were evaluated within three weeks of receipt. Management decisions were made and final implementation planning completed in 5½ months from the starting date.

READING 19 DISCUSSION QUESTIONS

1 How can simulation programs such as SCERT aid data-processing managers?

2 "SCERT is essentially a five-phase program." Discuss these phases.

SUMMARY OF CHAPTER 4

A feasibility study is made by an organization to determine the desirability of using a computer to achieve specified goals. Technical, economic, and operational aspects must be evaluated during such a study. One or more of these aspects have been considered in each of the readings just presented. Failure to plan properly for computers subjects the firm to probable financial loss; careful study, on the other hand, may yield positive benefits and may help the firm avoid common mistakes.

The steps in the feasibility-study approach are to (1) identify the scope of the roblem and the objectives to be gained, (2) gather the facts on current perations, (3) analyze these facts and determine suitable alternative procedures, 4) choose the most appropriate alternative, and (5) follow up on the decision.

In a broad sense, the end result of a computer feasibility study is a single lecision—to use or not to use a computer. But as we have seen in this chapter, here are an uncountable number of decisions which must be made by the study eam during the course of its work. The success of the information-processing ystem produced depends on the quality of these decisions.

If a decision is made to acquire a computer, a bewildering number of technical reparation tasks must be accomplished before the conversion to the computer an be completed. Personnel must be selected and trained; data-processing tandards must be established; programs must be written, documented, tested, nd debugged; file conversion must take place; the physical site for the quipment must be readied; and the actual changeover must be accomplished. Many months are required to perform these tasks. Computer vendors and onsultants may be of assistance in the performance of some of these jobs.

ORGANIZATION AND THE COMPUTER

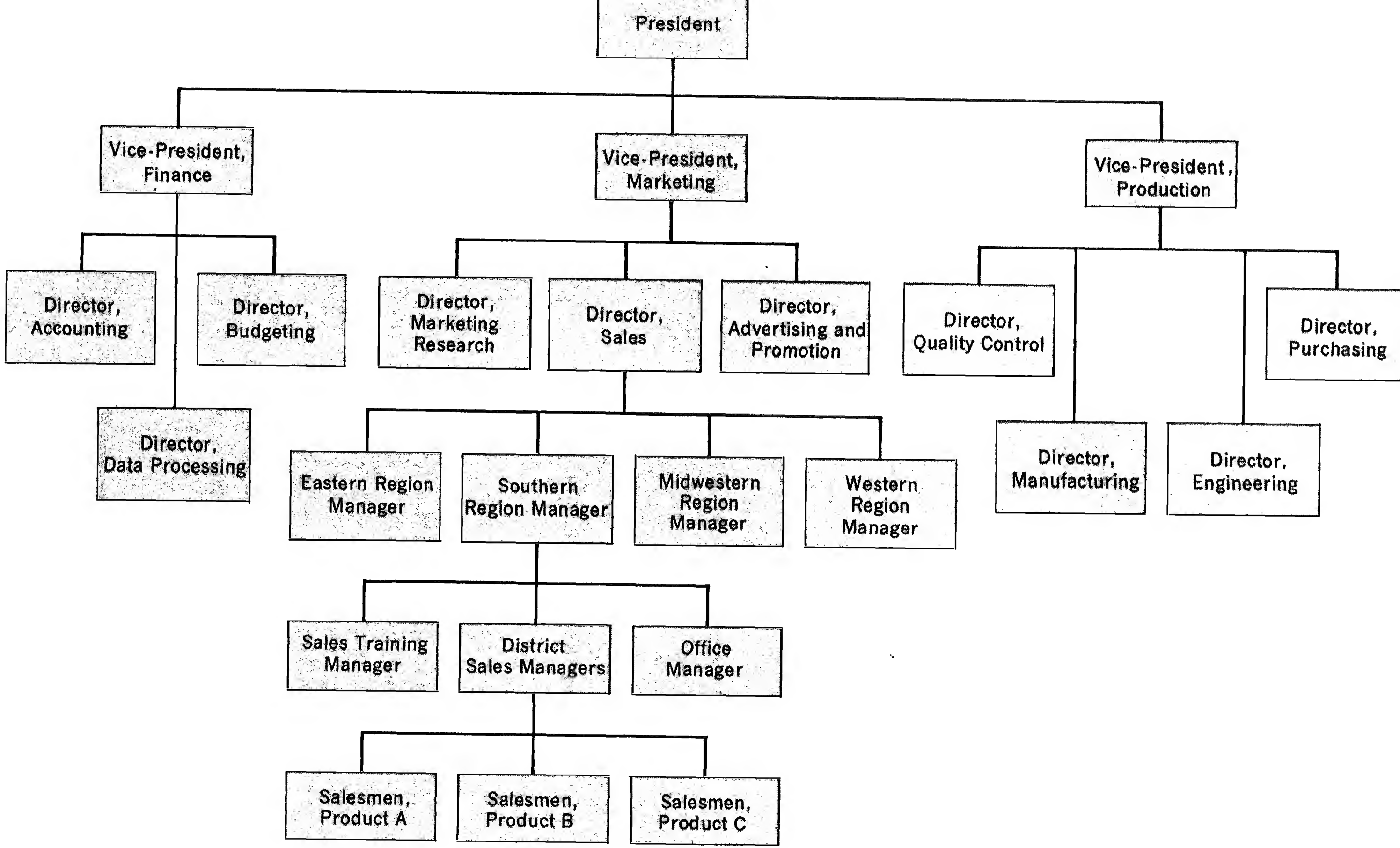
In this chapter we come to grips with the question of the present and potential consequences of computers on the environment in which managers work, i.e., with the impact of computers on the organizational structure of business. Furthermore, since managers work in such an environment, it is clear that anything which affects organizational structure is also of vital interest to them. Following a brief discussion of a few *organization fundamentals,* we shall study *the organization of data-processing activities* and *the computer's impact on future organization.*

ORGANIZATION FUNDAMENTALS

ORGANIZATIONAL STRUCTURE

The organizing function, you will recall, involves the grouping of work teams into logical and efficient units in order to carry out plans and achieve goals. If work units are to operate efficiently, each unit member must know what his job includes and what position he occupies. The *formal*[1] organizational (or *authority*) structure is represented by an *organization chart* which indicates, by position titles, the place in the organization of each job, the formal lines of authority and reporting relationships among positions, and the assigned role of the work unit in the total structure. Figure 5-1 shows the organizational chart of a hypothetical manufacturing firm. In this example, work units are grouped by

[1] There is also the important concept of the *informal* organization. This type of organization occurs naturally and voluntarily as a result of the interaction of employee groups. Although this subject is generally beyond the scope of this text, we will have some points to discuss about informal organization in Chap. 6.


President
Vice-President, Finance
Vice-President, Marketing
Vice-President, Production
Director, Accounting
Director, Budgeting
Director, Data Processing
Director, Marketing Research
Director, Sales
Director, Advertising and Promotion
Director, Quality Control
Director, Manufacturing
Director, Engineering
Director, Purchasing
Eastern Region Manager
Southern Region Manager
Midwestern Region Manager
Western Region Manager
Sales Training Manager
District Sales Managers
Office Manager
Salesmen, Product A
Salesmen, Product B
Salesmen, Product C

type of work (finance, marketing, and production), by *geographic area* (regional and district sales offices), and by *product line*. Of course, a logical and efficient organizing scheme for one company may not be desirable for another.

An organizational structure must be flexible because of constantly changing technological, social, and economic factors. We saw in Chapter 2 that such factors may bring about the introduction of new products and processes, may cause changes in markets and buying habits, and may result in company growth or decline. When a computer is introduced into an organization, it may take over a large part of the work of several departments. When there is no longer a valid reason for some units to continue to exist, changes should be made in the organization to avoid duplication and waste. Unless careful planning precedes such changes, however, they are likely to produce efficiency-robbing employee resistance in the affected departments.

CENTRALIZATION OR DECENTRALIZATION

The level in the organization structure where significant decisions are made can vary. The concept of *centralization of authority*[2] refers to a concentration of the important decision-making powers in the hands of a relatively few top executives. *Decentralization of authority*, on the other hand, refers to the extent to which significant decisions are made at lower levels. In very small organizations, *all* decision-making power is likely to be centralized in the hands of the owner-manager; in larger firms, the question of centralization or decentralization *is a matter of degree*—i.e., it is a question of how much authority is held at different levels. The extent to which authority is delegated to lower levels depends, in part, on such factors as: (1) the managerial philosophy of top executives; (2) the growth, size, and complexity of the business; (3) the availability of qualified subordinates; and (4) the availability of quality information and adequate operating controls. Since change may occur in all of these factors, it is apparent that the degree of authority centralization is also subject to revision.

In addition to centralization or decentralization of *authority*, it is also possible to use these terms in connection (1) with company operations in a *geographic sense*, and (2) with *activities to be performed*. In the discussions which follow, *it is important to remember that an organization may be centralized in one sense of the term and not in others.* For example, it is possible for the *data-processing activities* of a business to be concentrated at a central point to economize by using a large-scale computer. But this approach may have *little or no effect* on the degree of authority or geographic concentration. To illustrate, a sales

[2]Authority is defined here as the right to give orders and the power to see that they are carried out.

manager, located a thousand miles from corporate headquarters, may have the authority to make important decisions. With the availability of quick-response systems, however, it may not matter to him that the information which supports those decisions was prepared by a centralized computer. Thus, in this case we have centralization of data-processing activities combined with geographic and authority decentralization.

ORGANIZATION OF DATA-PROCESSING ACTIVITIES

Prior to the introduction of computers, data-processing activities were generally handled by manufacturing, marketing, and finance divisions on a separate and thus decentralized basis. But such developments as (1) the creation and improvement of online storage devices, (2) the introduction of quick-response systems, (3) the direct connection of remote stations to distant processors by means of high-speed data-communication facilities, and (4) the design of broader systems which cut across organizational lines have made it possible to centralize data-processing activities *if* company needs are best served by such action. Thus, many firms must now decide to what extent (if any) they will centralize their data-processing operations. Should small computers be used by individual organization units, or should these units furnish input to (and receive output from) one or more central computer centers which can be established to process data originating at many points?

ADVANTAGES OF CENTRALIZED DATA PROCESSING

The considerations in favor of the centralized approach are as follows:

1 *It permits economies of scale.* With adequate processing volume, the use of larger and more powerful computing equipment may result in reduced operating costs. A lower unit cost for each item processed may be achieved by lower total charges for personnel and equipment.

2 *It permits other economies.* Duplication in record storage and program preparation may be eliminated; less expensive standardized forms can be used; and site preparation costs may be reduced since fewer sites are involved.

3 *It facilitates necessary systems integration.* For example, achieving company-wide agreement on customer code numbers is a necessary step in integrating the procedures required to process customer orders. Such agreement is more likely to occur for efficiency reasons when order processing is handled at a central point. We have also seen that an integrated, central corporate data bank makes it possible for managers to probe files and obtain timely information.

4 *It has certain personnel advantages.* It may be possible to concentrate fewer skilled programmers at a centralized site and thus make more effective use of their talents. A sizable operation may offer more appeal to highly qualified

computer specialists. Thus, recruiting may be simplified and a professional group will be available to help train new personnel.

5 *It permits better utilization of processing capability.* With a centralized operation, *companywide* priorities can be assigned to processing tasks. Those jobs which are of greatest importance are, of course, completed first. With a decentralized approach, however, low-priority work may be processed in one division with excess capacity, while in another division a higher-priority application may be left unfinished because of inadequate processing capability.

In view of these benefits, it might seem that a decision to follow a centralized approach would be automatic. Yet there are limiting factors in centralization which may cause a company to follow a more decentralized path. These limitations are implicit in the following discussion of the advantages of decentralization.

ADVANTAGES OF DECENTRALIZED DATA PROCESSING

Included among the possible advantages of decentralization are:

1 *Greater interest and motivation at division levels.* Division managers in control of their own computers may be more likely (a) to maintain the accuracy of input data, and (b) to use the equipment in ways which best meet their particular operating needs. Greater interest and motivation, combined with greater knowledge of division conditions, may produce information of higher quality and value even though the unit processing costs may be higher.

2 *Better response to user needs.* The systems standardization typically required for centralized processing may not be equally suitable for all divisions. With decentralization, special programs can be prepared to meet exact divisional needs. In addition, although a smaller machine will probably be slower than the centralized equipment, it should be remembered that central machine time must be allocated to several users. Information considered important to one division may be delayed because higher priority is given to other processing tasks. Thus, the fact that a smaller machine allows for prompt attention to a given job may lead to faster processing at the division level.

3 Reduced downtime risks. A breakdown in the centralized equipment or in the communications links may leave the entire system inoperative. A similar breakdown in one division, however, does not affect other decentralized operations.

TREND TOWARD CENTRALIZATION OF DATA-PROCESSING ACTIVITIES

There is no general answer to the question of whether or not a company *should*

centralize or decentralize its processing. In the final analysis the decision usually involves a trade-off between motivational values and responsiveness to division needs, on the one hand, and operating costs on the other. A centralized system may reduce costs, but it is sometimes less responsive to user needs. The reverse is true in the case of decentralization.

It is appropriate to mention here, however, that the present trend is toward the creation of *central computer centers* to achieve the advantages outlined earlier. Smaller firms have little choice in this matter, since their organizational units do not have sufficient volume to justify separate machines. Because of the difficulties involved, very large organizations have generally not created single, huge, installations. Rather, they have often achieved a greater degree of centralization by establishing several regional data centers. Some executives who choose to follow the *centralization* route are hopeful that online terminals will give operating managers a sense of control over their information needs and will encourage them to take a proprietary interest in data processing. Firms with centralized hardware may also achieve greater interest and motivation at operating levels by maintaining some systems analysis operations on a more decentralized basis. This can be a logical arrangement because (1) divisional systems analysts may have a better understanding of the information needs of the division, and (2) this approach can effectively counter the argument from division managers who hold that, since systems design was beyond their control, they cannot be held accountable for design results.

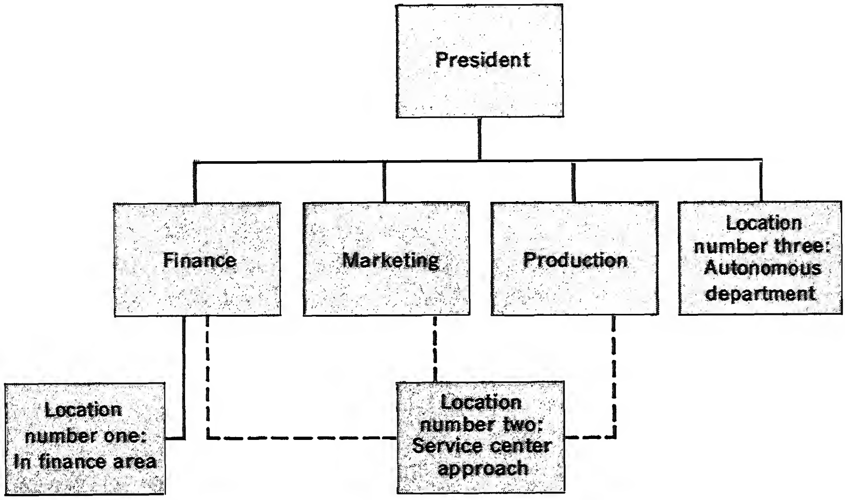
COMPUTER DEPARTMENT ORGANIZATIONAL LOCATION

Each business must determine the proper organizational location for its computer department. What is "proper" depends, in part, on the size of the organization, the applications to be processed, the degree of systems integration achieved and sought, and the importance attached to information systems by top executives. Figure 5-2 shows a simplified version of the chart presented in Figure 5-1. Three possible locations for the computer department are designated. Let us look at each of these arrangements.

LOCATION NUMBER ONE The computer department is found to be a part of the finance function in a majority of businesses.[3] The reason for the popularity of this location is not hard to understand. Historically, the accounting department was often the first to see that a computer could be used to process large-volume applications such as customer billing. Since most of the

[3] We see, for example, in the reading entitled "The Computer Comes of Age," at the end of Chap. 3, that in 58 percent of the firms surveyed the "top computer executive" reports to a financial officer.

FIGURE 5-2 ALTERNATIVE COMPUTER DEPARTMENT LOCATIONS



early applications were of a financial nature, the computer was most often placed under the control of financial managers. Of course, in businesses engaged in large-scale scientific and engineering projects, a computer may be located in research and engineering departments because these departments recognized the advantages of computer usage. To a considerable extent, then, the organizational location of the computer depends on its original sponsor.

As long as the processing requirements of the financial area are sufficiently large to keep the computer busy, and as long as no other departments have the need or desire to use the computer, then location number one is satisfactory. However, with modern equipment it is unlikely that one area can utilize all the computing capacity, and it is also unlikely that nonfinancial departments will not have a need for information which the computer can deliver. Therefore, the computer department is usually required to process nonfinancial applications.[4]

The following are possible drawbacks associated with the finance-area location:

1 *Possible lack of objectivity in setting job priorities.* Computer-department personnel may tend to concentrate on accounting applications at the expense of important nonfinancial jobs. The data-processing manager is likely to give more

[4] In some companies, *each* functional area may support a computer on a decentralized basis (although this tends to defeat systems-integration goals and is more costly). But when a corporate division is a relatively *self-contained* operating unit—i.e., when the division manager is responsible for finance, production, and marketing activities—and when a single computer is to serve the entire division, then the organizational situation may be comparable with that of the majority of computer-using firms.

attention to the wishes of his boss, a financial officer, than he does to the heads of marketing or production.

2 *Possible limited viewpoint.* The computer department may continue to be staffed and managed by people whose viewpoint is limited primarily to accounting. A corporatewide orientation may be lacking.

3 *Possible lack of organizational status.* Organizational status and authority are lacking when the top computer executive is interred several echelons down in one functional area of the business. A firm can expect little in the way of needed systems integration when the data-processing manager has little or no power to bring about interdepartmental changes and compromises. As John Diebold, a leading consultant, writes:[5]

> *Assistant controllers equipped with the best computers in the world are not going to make the vision of applied information technology a reality very often. They are buried too deep in one leg of the business. They lack status. They lack authority. . . .But most important of all, they lack the entrepreneur's view of the enterprise as a whole.*

LOCATION NUMBER TWO One approach which can avoid the lack of objectivity in setting job priorities is to establish a company "service center" to handle the various tasks. Each department may be charged its proportionate share of center costs. While the center manager may report to a neutral top-level executive or to an executive committee, the service center basically occupies a position which is on the periphery of, or outside, the main organizational structure.

The main limitation of this type of organizational arrangement for business data processing is that the center manager generally has little status or authority outside his own department. Thus, little attempt is made to initiate systems improvements or to develop integrated systems; a fragmented, every-department-for-itself approach may be expected.

LOCATION NUMBER THREE In order to realize the full potential of the computer, a majority of information-processing authorities believe that an independent computer department should be established as shown in location three of Figure 5-2. Such factors as company size, the extent of computer usage, the managerial personalities involved, and the existing spirit of cooperation make it impossible to state that location three is best for all firms. But there are persuasive reasons for concluding that this is perhaps the most desirable location in the case of medium-sized and larger concerns which seek to develop effective

[5] John Diebold, "ADP: The Still-Sleeping Giant," Harvard Business Review, vol. 41, p. 63, September-October, 1964.

systems integration. Three of the reasons which can be given to support this conclusion are that this location:

1 *Reflects the corporatewide scope of information.* Independent status is needed to give impartial service to all organizational units which receive processed information. An interdepartmental viewpoint is required of data-processing personnel.

2 *Confers organizational status.* The top computer executive should have a strong voice in determining the suitability of new and existing applications, should probably set processing priorities, and should study and make necessary changes in corporatewide systems and procedures in order to achieve better integration. To perform these duties, the information manager must have the cooperation of executives at the highest operating levels. In the event of significant change, such cooperation may not be received unless the information manager occupies a position which is no lower in the organization than the highest information-using department. Furthermore, in the event of a dispute, the information manager should report to an executive who is at a higher level than any of the disputing parties. Since the parties who resist significant integration changes may be vice-presidents, the top computer executive should probably report to the president (or to the top executive of a division in the case of a decentralized processing department), or to an executive or administrative vice-president. One computer department head, with the title of administrative services manager, told the author that when several changes were made in his company, there was a great amount of corporate politics involved as well as resistance from several vice-presidents. The administrative services manager reported directly to the president, however, and the president backed the changes.

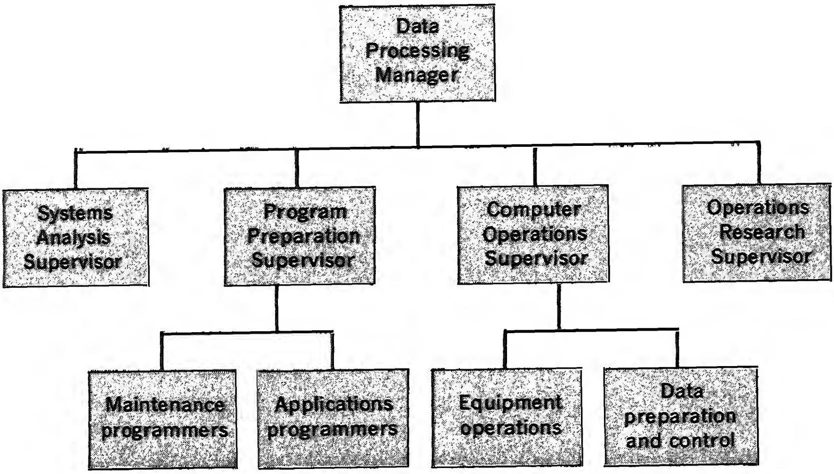
3 *Encourages innovation.* Personnel of an independent department can be encouraged to recommend improvement and change whenever and wherever the opportunity arises. They may also be encouraged to introduce, for the greatest total benefit, fresh ideas which may upset certain conventional approaches.

COMPOSITION OF COMPUTER DEPARTMENT

The composition of the computer department depends on the scope and magnitude of the data-processing work which must be performed and on the extent to which this work is carried out by the computer department. It is usual to include the activities of systems analysis and design, program preparation, and computer operation in the computer department. Although other logical arrangements might possibly be used, Figure 5-3 provides us with an organizational framework from which combinations or further subdivisions of activities may be made as needed.

SYSTEMS-ANALYSIS SECTION Because of the close cooperation which must exist between programmers and systems analysts, it is generally desirable

FIGURE 5-3 POSSIBLE COMPOSITION OF COMPUTER DEPARTMENT



that both groups report to the same executive to minimize friction. The systems-analysis section acts as the vital interface between outside operating departments and the other sections in the computer organization. As noted earlier, it may be desirable to maintain systems analysts in the operating divisions of large firms with centralized computer centers.

PROGRAM-PREPARATION SECTION There is no reason why a single supervisor could not be in charge of both systems analysis and program preparation.[6] In medium-sized and larger organizations, however, a separate supervisor is frequently found. The programming function is sometimes subdivided into (1) the preparation of new applications and (2) the maintenance of existing programs. Authority may also be given to one or more individuals to make sure that proper standards and documentation levels are maintained.

COMPUTER-OPERATIONS SECTION The function of this section is to prepare the input data and produce the output information on a continuing production basis. Multiple shifts may be required. The control of equipment time and the scheduling of processing activities are an important part of the duties of the operations supervisor. Controls must also be established to make sure that input data are accurate. Computer operators, operators of peripheral equipment, keypunch operators, and media librarians are found in this section. The total number of employees may be large, and turnover is likely to be high;

[6] For example, see the organization scheme prepared by Michael Moore in the reading at the end of Chap. 7 entitled "EDP Audits: A Systems Approach."

thus, personnel-management considerations may occupy a significant part of the operations supervisor's time.

OPERATIONS-RESEARCH SECTION This section may logically be assigned to some other corporate planning element concerned with the overall study of company operations. But since the use of computers and data files is required to support many of the mathematical models which OR personnel create, there may be good reasons for assigning them to the computer department for coordination purposes.[7] Certainly, the work of the OR and systems-analysis groups should be closely coordinated. As H. Warren White points out:[8]

> *Experience indicates that the design of mathematical models, for example, must be accomplished through close liaison with the systems specialist, as models can serve a useful purpose only if the systems provide the necessary data to fit in the model.*

THE COMPUTER'S IMPACT ON FUTURE ORGANIZATION

We saw earlier in the chapter that the trend today is toward centralization of data-processing *activities.* But a broader issue, and one which should be of particular interest to those management students whose careers lie before them, is what effect computer usage will have on the centralization or decentralization of managerial *authority.* It is this issue which will receive our attention for the remainder of the chapter.

Before computers came along, the general trend was toward *greater decentralization* of authority. To some top managers decentralization was more a matter of necessity than of choice. They often found themselves in a position where they could (1) wait for the necessary supporting information to arrive from lower levels before making a decision (in which case company reaction time suffered and opportunities were lost); (2) place their trust in experience, intuition, and their horoscope and make the decision without proper supporting information; or (3) delegate the authority to make the decision to a lower-level manager who was closer to the situation calling for the decision and who could thus be expected to react in a prompt and more informed manner. Given these alternatives, it is understandable that, as businesses grew in complexity, the third path was frequently chosen.

[7] See the section entitled "Activities Managed" in "The Computer Comes of Age," a reading at the end of Chap. 3.

[8] H. Warren White, "Electronic Data Processing: A 10-year Perspective," *NAA Bulletin,* vol. 45, p. 13, April, 1964.

With the introduction of quick-response computer systems, however, information may be processed and communicated to top executives at electronic speeds; reaction time may be sharply reduced; and thus the *need* for decentralization of authority may be lessened. But although new systems may make it possible to reconcentrate, at the upper echelons, authority and control previously held at lower levels, there is *no reason* why the information output cannot be disseminated to lower-level managers to provide them with better support for decision-making purposes. Professor Glenn Gilman expresses this point succinctly when he writes:[9]

> *The computer can serve equally well to support a move toward greater decentralization as toward greater centralization. If change in either direction develops, it will be the result of managerial choice, as it always has been. The computer's role in this respect is neutral—except as it offers the possibility to do what ought to be done in any case.*

Computer usage has thus far supported both a centralized and a decentralized organizational philosophy. But what will be the future effects on organizational structure as more sophisticated management information systems are developed? In making their "managerial choice," will it seem clear to top executives that one approach has definite advantages over the other? In other words, will the organizational preferences and philosophies which are valid and suitable today be equally valid tomorrow when there will be widespread use of the revolutionary business information systems described in Chapter 2? Will top executives with a decentralized organizational philosophy have the necessary time and expertise to switch to the greater-centralization-of-authority approach if the total information needed to make an important decision is consolidated at one place? Or will such information be communicated to several managers for separate decisions?

There cannot, of course, be any final answers to such questions at this time. Still, it is possible and desirable that we have an understanding of the conflicting viewpoints, speculations, and predictions which surround these questions. It is no understatement to say that the future career of every business student will be affected in some way by the ultimate answers.

CENTRALIZATION OR DECENTRALIZATION OF AUTHORITY?

There are three schools of thought on the question of the effect which computer usage will have on the centralization or decentralization of managerial authority. The first school believes that the computer *need have little effect* on organizational structure; the second school believes that *greater decentralization*

[9] Glenn Gilman, "The Computer Revisited," *Business Horizons,* vol. 9, p. 89, Winter, 1966.

of authority may be encouraged; and the third group takes the position that *recentralization* of authority is inevitable. Let us examine each of these positions.[10]

NO-NECESSARY-CHANGE SCHOOL After looking at the inconclusive effects of computer usage up to the present time, the proponents of this viewpoint maintain that the computer is essentially neutral with respect to the organizational structure.[11] It is their position that the computer can act as a catalyst to help a firm move in whatever direction it feels it must go. The factors influencing the direction include market changes, competitive changes, organizational flexibility, and managerial philosophy.

In the short run, and as long as the computer is used primarily for the purpose of processing more or less routine applications, the available evidence seems to indicate that the viewpoints of this school will remain correct. However, proponents of other views are assuming that more sophisticated uses of computers will be developed. New systems, it is felt, will cause significant changes in competitive positions, in organizational environment, and in the philosophy of top executives; such changes, so the argument goes, will persuade top executives that it *is necessary* to move in a specific direction; and such changes, it is held, will produce pronounced authority trends which are not now apparent.

DECENTRALIZATION SCHOOL Some writers believe that the future trend may be toward decentralization of authority. The availability of adequate controls is a factor in determining the extent of authority delegation. Managers are more likely to delegate decision-making powers to subordinates when they can be reasonably sure that the delegated authority will be handled properly. The computer makes it possible for systems to be designed which can quickly indicate to top executives when actual performance deviates from what was planned. Thus, by providing better control, the computer may make it possible to eliminate one important objection to decentralization. Furthermore, as the computer relieves them of certain routine aspects of their jobs, the subordinate managers are able to concentrate on their more important duties. The net effect will be that upper-echelon executives will have greater confidence (1) in the ability of subordinates and (2) in their own ability to control subordinate performance properly. The conclusion of this school, therefore, is that the decentralization philosophy will be reinforced.

[10]More detailed statements in support of some of these positions will be found in the readings at the end of this chapter. See also Charles A. Myers (ed.), *The Impact of Computers on Management,* M.I.T. Press, Cambridge, Mass., 1967.

[11]Most authorities agree that *the hardware itself is, indeed, neutral.* The point being disputed, however, is that *the emerging systems* which the computer will support *may not be so neutral.*

CENTRALIZATION SCHOOL This group believes that the computer makes it possible for those executives whose leanings are toward centralized management to bring back under their own jurisdiction the authority which they were forced to delegate as a matter of necessity. There is little argument against this point. More controversial, however, is this group's belief that when *other* top executives realize that their new management reporting systems[12] can uncover problems at lower levels and can place at their fingertips vital decision-supporting data, they will be unable to resist making operating decisions even if they had no intention of doing so when the systems were designed.[13] Subordinate managers will thus be bypassed, not as many of them will be needed, and delegated authority will be recovered. Since the new systems will be capable of taking over various functions previously performed by subordinate managers, there will be a need to consolidate the remaining functions to produce new positions. The result of this reorganization will be to produce a *more flattened organizational structure*—i.e., there will be fewer managerial levels between the lowest supervisor and the top company executive.

EFFECTS ON MANAGERS?

Future changes in the organizational structure of business will have a direct bearing on managers who occupy places in that structure. Obviously, however, if there is controversy about future organizational patterns, there will also be disagreement about the effects of new computer systems on managers.

High-level executives, of course, will be affected; they may reassume some of the decision-making powers previously delegated to subordinates (centralization school); or they may, with a greater feeling of confidence, delegate additional authority to subordinates (decentralization school). The primary role of top managers lies in formulating company objectives and policies and in planning and guiding overall company strategy. Computer-based systems should help to remove some of the uncertainties from the usually unique and ill-structured problems which top executives face. But substantial changes in this top management role are generally not expected.

If significant reductions are made in clerical and/or production workers because of computer usage, it is to be expected that lower-level supervisory

[12] The types of reports included in these new systems may be (1) periodic *monitoring reports* which compare actual performance with planned expectations; (2) *triggered reports* which are prepared only when actual performance deviates too much from plans; and (3) *demand reports* which answer managerial probings (by means of, perhaps, online terminals) about the causes of triggered reports and about other special problems. See Richard G. Canning's article at the end of Chap. 3 entitled "Trends in the Use of Data Systems."

[13] This point is disputed. If true, it could present problems if lower-level decisions absorbed too much top-executive time so that higher-level planning activities were slighted.

reductions will also occur. However, the *foreman's* role of providing face-to-face communication, direction, and leadership to production-oriented employees is not expected to change, although the computer can relieve him of many of his clerical duties.

This leaves us then with the *middle management* positions[14] around which has been centered the bulk of the published speculation and argument. Although there are some who believe that computer usage will have no major or lasting effect on middle managers, it is possible to classify most of the comment into three categories. There are (1) those who believe that middle management positions will be *more rewarding and challenging* in the future; there are (2) those who see the prospects in a much more *pessimistic* light; and there are (3) those who occupy a *middle position* between optimism and pessimism.

THE GREATER-CHALLENGE VIEWPOINT Those holding to this viewpoint believe that future middle managers will be better educated, will be more creative, more confident, and better prepared to cope with rapid change, will be more mobile, and will tend to place their own professional standards above values deemed to be important by the organization which employs them.

Middle managers, like all managers, perform the functions of planning, organizing, staffing, and controlling. Optimistic prophets point out that less time will have to be spent on the controlling function because the computer can take over many of the clerical control activities—e.g., it can signal with a triggered report whenever actual performance varies from what was planned. Time saved in controlling will enable middle managers to devote more attention to planning and to directing the work of subordinates. More accurate and timely information supplied by the computer will enable middle managers to spend more time identifying problems, recognizing opportunities, and planning alternate courses of action. In this respect, then, their jobs will more nearly resemble those of chief executives. With more time to devote to departmental employee matters, improved morale may be expected and better communication should result. Furthermore, with more timely information at the middle managers' disposal, top managers will expect them to react more rapidly. This may call for frequent face-to-face coordinating conferences between managers. Such meetings foster better interdepartmental communication.

[14]*Middle managers* may be defined as those who are above the lowest level of supervision and below the highest level of a self-contained operating organization—i.e., they occupy positions between foremen and first-rung supervisors on the one hand, and company presidents, executive vice-presidents, and division managers of larger corporations on the other. Thus, the term "middle manager" is rather nebulous and is applied to a number of levels. The difficulties of generalizing about such a wide range of positions should be recognized; it is not at all certain that the paths leading from all middle management levels will lead in the same general direction.

In summary, a number of writers agree with Professor Peter F. Drucker:[15]

> *The computer will force us to develop managers who are trained and tested in making the strategic decisions which determine business success or failure. I doubt that the computer will much reduce the number of middle management jobs. Instead the computer is restructuring these jobs, enabling us to organize work where it logically belongs and to free middle managers for more important duties.*

THE PESSIMISTIC VIEWPOINT The pessimistic group takes the position (1) that middle management job content will be *less* challenging because of computer usage and (2) that the *number of* such managers will be *substantially reduced.* The argument of this group is as follows:

1 Many middle management decisions are highly structured and repetitive and are thus programmable on a computer.
2 Therefore, many planning and decision activities will move from middle managers and will be handled by the data-processing systems.
3 The need for middle managers will be greatly reduced; and the content of the remaining jobs at the middle levels will be less challenging, more routine, and more formalized than before.
4 Why will remaining jobs be less challenging? Because the tasks of middle managers will be divided. Duties requiring less judgment and skill will remain with middle managers; other tasks requiring the skilled interpretation of systems information will move toward the top levels.
5 Three administrative organizational layers may emerge. There will be the production-oriented workers and their supervisors who will prepare the computer systems input; there will be an elite group of systems and computer specialists who will perform the processing activities; and there will be a small group of top executives who will analyze the facts and make the necessary decisions. There will be a minimum of personnel transfers between these layers.

AN INTERMEDIATE POSITION Some writers agree with the viewpoint that in the future middle management jobs will be more rewarding and challenging, but they also believe that the number of such jobs will be significantly reduced. They are *optimistic about the job content* of the future middle management position; they feel that the occupant will find more freedom and creativity in it; but they are *pessimistic about the number of such managers who will be needed.*

This is the consensus position taken in a report published by the American Foundation on Automation and Employment. The report, based on 35 extensive

[15] Peter F. Drucker, "What the Computers Will Be Telling You," *Nation's Business,* vol. 54, p. 89, August, 1966. This article is found at the end of Chap. 3.

interviews with business, government, and academic leaders, states that computers have "... already cut deeply into the need for middle managers." And although there is as yet no evidence of widespread displacement in their ranks, the report warns that "the middle manager's job stability ... is subject to a far more serious threat and open to greater possibilities than past experience and expected trends in the immediate future would suggest."[16]

Those who are optimistic about *both* job content and number of positions generally belong to the *authority decentralization school.* Those who foresee a trend toward *centralization* of authority *may or may not* agree about the outlook for job content. But they usually do concur in the belief that the number of such jobs will be reduced.

It is fair to conclude that a majority of the published predictions at least agree that the future middle manager will function in a setting which is more intellectually demanding. Unlike the Dodo bird, he will not become extinct, although his numbers may become proportionately lower. The manager of today must upgrade his abilities if he is to meet the sterner challenges of tomorrow. And the business student of today must acquire an understanding of business systems and of the uses and limitations of computers if he is to compete effectively in the future managerial environment.

DISCUSSION QUESTIONS

1 (a) Why must an organizational structure be flexible?
  (b) What is an organization chart?

2 (a) What is meant by centralization of authority?
  (b) What factors determine the extent to which authority is delegated to lower management levels?

3 "An organization may be centralized in one sense of the term and not in others." Discuss this statement.

4 (a) What developments have made it possible to centralize data-processing activities?
  (b) What are the advantages of centralized data processing?
  (c) What are the possible advantages of decentralized data processing?
  (d) Why is the trend in the direction of centralization of data-processing activities?

[16] From a report entitled *Automation and the Middle Manager, What Has Happened and What the Future Holds,* published by the American Foundation on Automation and Employment. Quotations appear in *Administrative Management,* p. 54, June, 1966. For more details on this report, see the reading at the end of this chapter entitled "Middle Managers vs. the Computer."

5 (a) Identify and discuss three possible organizational locations for the computer department.
(b) What reasons can be given to justify the establishment of an independent computer department?

6 What activities are usually included in the computer department?

7 (a) Why has the general trend in the past been in the direction of decentralization of authority?
(b) How can computer usage reduce the need for decentralization?

8 (a) Discuss the positions taken by the three schools of thought on the question of centralization or decentralization of authority.
(b) Which school do you believe has the best argument?
(c) Why?

9 (a) Are you optimistic or pessimistic about the prospects for future middle managers?
(b) How do you think computer usage is likely to affect your career?

CHAPTER FIVE READINGS

INTRODUCTION TO READINGS 20 THROUGH 23

20 "The T-Formation" is a parody on computer organization and on acronyms. If there is a message in this reading, it is that the data-processing department should not achieve a position which is out of proportion to its real importance in the organization.

21 Will computers lead to a greater centralization of authority? How will computer activities be organized and placed in the total organization? What impact will the developing broader systems have on organizational structure? These are some of the questions considered by Professor Victor Z. Brink in this reading.

22 Donald L. Caruth takes the position in this paper that the impact of the total systems concept will be greatest in the middle management ranks, reducing them in number and importance. At the employee level, there will be a tendency toward depersonalization. The net effect on the organization structure will be a trend toward recentralization.

23 The future role of middle managers is the subject of this reading. Middle management resistance to technological change is found to be widespread; and a report released by the American Foundation on Automation and Employment is highlighted. The number of middle managers likely to be needed in the future is discussed.

READING 20 THE T-FORMATION*[1]

T. D. C. KUCH

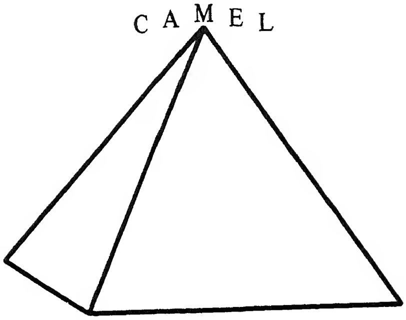
Teamwork, as we all know, is the most important aspect of business management. No amount of know-how or common sense can make up for poor teamwork at the top level. Gibbons and Smith[2] have shown that it is not the

*Reprinted from *Datamation,* vol. 11, pp. 49-50ff., May, 1965. Reprinted by permission from F. D. Thompson Publications, Inc., 35 Mason St., Greenwich, Connecticut. Mr. Kuch is the President of Kuch Konsultants Inkorporated (KKI).

[1]This paper is the substance of a talk recently delivered at a meeting of the Tab-Planners' Management Association (TPMA).

[2]L. Gibbons and J. W. Smith, "Organization of Business; a Summary of Progress in the COMATOSE (COmputerised MAnagement TOols and SErvices) Program." J. Data Q. Rev., 3:3 (1964).

FIGURE 1 A PYRAMID



personalities of the men in the team that contribute to good teamwork, but rather the Organization of the team. With proper Organization, and a properly-drawn Organizational Chart, *any* team can function to perfection.

The history of Organizational Theory to the present time has consisted of repeated attempts to update the classical Pyramid (see Fig. 1) for modern business use (see Fig. 2). The Pyramid, we all know, derives its stability from its broad base and triangular form. The first Pyramid was designed by an Egyptian management-consultant for the ruler, Rameses II. This Pyramid has lasted for thousands of years, furnishing an inspiring model for today's Top Management.

However, the Pyramid is clearly unsuited to this century. Its extreme stability entails lack of flexibility; its perfect symmetry fails to take account of the fact that some departments of a corporation, such as Data Processing, achieve a position on the chart out of all proportion to their real importance.

One of the variations on the Pyramid has been the Modified-P (Single Wing), which is shown in Fig. 3.

The DP Department shows the result of several years of intensive growth, which has made its size eclipse that of the parent organization. At this point one of two things can happen. Either the leftmost Pyramid will fall, lacking a Broad Base, or the DP Department will swallow it up, turning the whole company into

FIGURE 2 ANOTHER PYRAMID

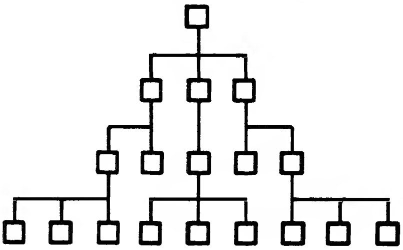
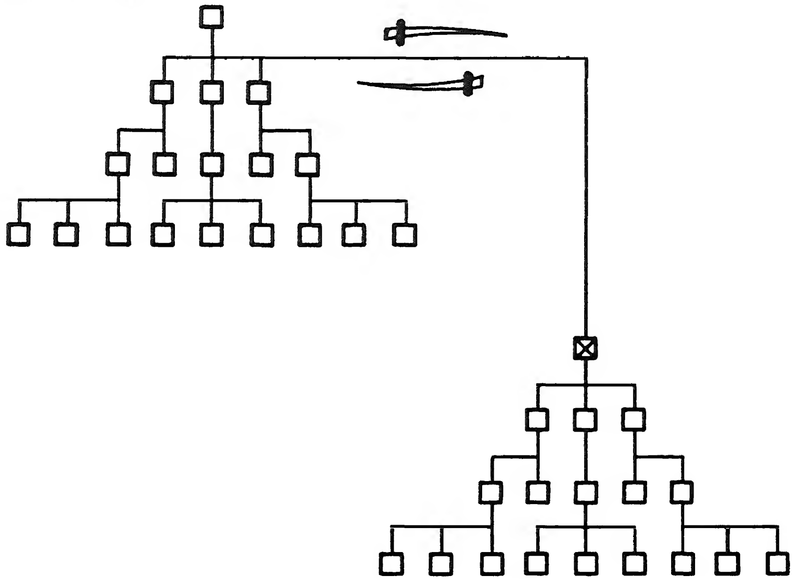


FIGURE 3 MODIFIED-P (SINGLE WING) SHOWING DP DEPARTMENT ON THE RIGHT.



a Service Bureau. At the stage shown in Fig. 3, one of these alternatives is about to happen. This is symbolized by the daggers, which indicate a Reciprocal Relationship. All this would have been avoided had the corporation used the T-FORMATION.[3]

In Fig. 3 we see that the only deterrent to the DP Department's growth is the limitation imposed by the Chief Executive. If he can be cowed, the DP Chief is given free-rein for empire building. This tends to happen far more often than one might expect, given a chance distribution of computers, empire builders, and Chief Executives.

In the T-FORMATION, however, there is no danger of this. In the T-FORMATION, by the time a manager has acquired a position of power, he is bereft of all subordinates but one (see Fig. 4).

We see in this diagram that the DP Chief must cow *five* executives before attaining his goals, which invariably are (1) a larger staff, (2) a bigger, more expensive, faster computer with more buttons, lights, bells and whistles, and (3) a private secretary, preferably a divorcee with her own apartment. It will readily

[3]This New Concept was developed by KKI as an unanticipated byproduct of our management science software package PRATFALL (PRogrammed Administrative Techniques For ALleviating Logjams). This catchy term was generated by our program ACRONIM (Automatic Computer ROutine for Names In Miniature).

be seen that (2) leads inevitably to (1), which in turn leads to (2) again, and so on. Goal (3) has little relation to (1) and/or (2). In fact, realization of this has led some Chief Executives to bestow (3) upon their DP Chiefs, so that they will have little time to ponder the best ways of attaining (1) and/or (2).

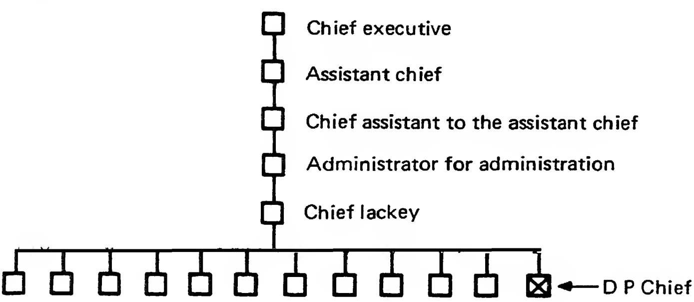
In the T-FORMATION, the DP Chief can advance only by becoming Chief Lackey, then Administrator for Administration. Once he becomes Chief Assistant to the Assistant Chief, his influence is limited to an occasional browbeating of the Adm/Adm, who invariably doesn't listen to him anyway. He will attempt first to sway, then to replace the Assistant Chief. This, in spite of by now long odds, he may do. In the position of Assistant Chief, he will attempt to sway the Chief Executive. It is assumed that by this time *all* lower positions will have been usurped by DP personnel.

In time (*per impossibile*!) he may even become Chief Executive, a result which the T-FORMATION is designed to prevent, but which, in a few cases, may happen. His broad background of DP experience, and his far-reaching and powerful mind, will soon go to work.

He will expand the corporation as fast as possible, hiring employees in anticipation of possible future needs, buying more and bigger computers,[4] extra

[4] Kuch's Extension of Parkinson's Law states that, in a Healthy Business, a larger and faster computer will be purchased when ½ the capacity of the present computer is used at peak-load time. The new computer will invariably have 3/2 the throughput capacity of the old one. To avoid much of the ensuing embarrassing idle time, tab-shop jobs will be written in COBOL, ALGOL, or HADACOL (Half-Adequate Data-ACquisition Oriented Language) and put on the computer. For this purpose, we here at KKI have developed and copyrighted DOPE (DeOPtimised Edit), a COBOL program which reads punched cards and checks for a group-mark in column 80. It requires 45 minutes to compile and two seconds per card to execute. We guarantee issuance of source-language changes at least once a week. It is ideally suited to Healthy Business.

FIGURE 4 T-FORMATION, SHOWING DP DEPARTMENT IN ITS PROPER PLACE (FOR PRIVATE INDUSTRY ONLY; FOR GOVERNMENT AGENCIES, TURN THE DIAGRAM UPSIDE-DOWN).



bells and whistles, etc., until the whole operation becomes as solid and immobile as the pyramids at Gizeh, and just as relevant.

READING 21 TOP MANAGEMENT LOOKS AT THE COMPUTER*

VICTOR Z. BRINK

How does top management view the computer in making its major or organizational decisions? Are computers with their new and powerful capabilities exerting a positive force on top management for either the design of new types of organizational structure, or for the significant modification of existing organizational relationships? Or are organizational decisions still determined in the main by other factors, with computers helping to support and make effective the organizational arrangements selected on the basis of other management needs? Many well-informed individuals—managers, educators and computer professionals—think the first position describes substantially what is happening, or at least what will happen in the near future. On the other hand, there are equally well-informed experts who feel that the second view more accurately describes the situation.

The question is part of the enduring quest for the most effective design of organization. How should a corporate management divide the work pertaining to the organization's activity and assign various portions of the total corporate responsibility? How should the same corporate management assure the most effective coordination and integration of those assigned responsibilities for the accomplishment of the organization's goals and objectives? The problem is an old one that has faced all managers in every age and in every era. But the problem is new always in the sense of needing adaptation and reappraisal in the light of changing conditions at any given point of time.

While today's conditions involve many new developments, certainly one of special significance is the introduction of computers and their related applications. These new computer developments deal with the identification, analysis, and presentation of information incident to management decisions and action. The extent of their influence upon organizational policy and related management practice is increasingly large.

Here then are the key questions: To what extent are computers and their utilization in fact determining current and projected organizational plans? And if

*Reprinted from *Columbia Journal of World Business,* pp. 77-85, January-February, 1969. Reprinted by permission from the *Columbia Journal of World Business.* Professor Brink is on the faculty of the Columbia University Graduate School of Business.

not the determining factor, what indeed is the real role of computers in enabling management to carry out its organizational plans more effectively? These key questions provide the setting for more specific questions:

1 Will computers lead to a greater centralization of authority and decision making?
2 Will the profit decentralization approach be weakened or strengthened?
3 How will the role and related organization of staff versus line activities be affected?
4 How will the computer activities be organized and placed in the total organization?
5 What types of human problems will be involved and how can they best be dealt with?

These more specific questions can be made more meaningful if the key conclusions which relate to the impact of computers upon major organization actions are first summarized.

1 THE MAJOR CAPABILITIES OF COMPUTERS FOR THE MODIFICATION OF ORGANIZATIONAL STRUCTURE

The technological capabilities of computers for the collection and utilization of information as a basis for a wide range of decision making and operational arrangements have been demonstrated beyond question. These capabilities make it possible to organize and administer businesses in many new and different ways, especially as respects more centralized and more automated control of major portions of the corporate operations. These capabilities are important both in making such organizational changes possible and also as motivation to managers to avoid undesired centralization through better performance throughout the organization.

The fact that these capabilities do exist, and will increasingly exist as further progress is made in the computer technology, may have been the unwarranted basis for many of the predictions that businesses will in fact come to be much more centralized, that middle management will tend to contract, and that there will be major personnel displacements, especially at the clerical and middle management levels. There is the assumption that management will elect, if not be forced, to exploit in an organizational sense the apparent economies of the emerging centralization capabilities.

2 THE FORCES WHICH OPPOSE CENTRALIZATION

There are, however, a number of forces which tend to oppose centralization. In the first place, business is complex, and it is extremely difficult in both a technical and economic sense to develop comprehensive systems and programs

which are satisfactory in coping with those complicated operations. Additionally, the trend of the times is for the development of products and services which will cater with greater specification to an expanding scope of actual and perceived human needs. This latter trend extends the complexity of corporate operations at a pace which the system builders and computer programmers cannot fully match—again, both in terms of technology and economics.

Related to this trend but warranting separate identification is the trend of corporations to diversify to obtain the benefits of improved investment opportunities, and to enjoy greater growth of sales and profits through entry into broader types of markets and operational endeavors. Since individual businesses normally have different kinds of operational problems, the possibilities of centralized direction and control become all the more difficult. Computer applications are, of course, subject to the same problems and constraints—and even more so.

Finally, there is a major force opposing centralization in the form of the human factors which operate in a variety of ways. Personnel at all levels need to be motivated. We can best induce the desired motivation when we give employees challenging and meaningful tasks. Normally, this can be best accomplished when work is divided in such a way that the individual person has considerable control over a substantive portion of the work and can see the results of his own performance. While this is true of personnel at all levels, it is particularly important to managers, and especially to managers of decentralized profit centers.

Adjustments in the scope of the decentralized role can be made and accepted, but these adjustments always involve a price and at some point a price which is too high in terms of the overall corporate performance and results. As a general rule, the computerized systems which are company-wide tend to curtail the freedom of operations and flexibility of control a manager would possess under a noncomputerized type of operation. Similarly, at a lower organizational level, the computerized systems application has a similar kind of effect on the lower level managers and supervisors. Necessarily, this constitutes a price which must be considered when a particular systems approach is selected.

3 THAT THERE WILL BE AN EVOLVING TRADE-OFF BETWEEN COMPUTER CAPABILITIES AND OTHER CONSIDERATIONS

This view of an evolving trade-off is definitely at odds with the frequently expressed and more positive predictions of dramatic consequences of computer utilization. No doubt businessmen will, as good businessmen, press to exploit, so far as practicable, the existing and further emerging computer capabilities—something that competitive forces will help assure—but they are also cognizant of the powerful nature of other considerations that strengthen the organization

and will move cautiously in any action that would weaken them. What occurs is something which is more evolutionary than abrupt and which adjusts itself gradually to the changing factors. The development of major computer applications has proved to be far more complicated than was generally expected, and the time required—usually involving several years each for major computer applications—provides for an orderly and efficient reconciliation of the opposing factors. The needed time is especially important to protect the ongoing operations and to adjust to the human considerations which are always so importantly involved.

4 THAT THE ROLE OF COMPUTERS IN ORGANIZATIONAL DECISIONS IS MORE SUPPORTIVE THAN CAUSAL

The evolutionary development of the trade-off between opposing forces suggests a secondary sequential conclusion: computers and computer applications currently, and for at least the foreseeable future, are not major determinants of general organizational structure. Rather, computers are and should be regarded as a tool and aid to help managers organize as they see desirable in response to other more corporate considerations. They are essentially a means to help managers to manage as they themselves wish to manage. This view must not be construed to preclude consideration of computer capabilities in making organizational decisions. It does stress the less dramatic incidence of computer installations and looks to the evolutionary development of such relationships. The point is reemphasized that computers must be the servant and not the master of management executives—a point that is useful for both management executives and computer personnel to understand and to respect.

The support for these overall key conclusions is provided by the results of interviews and research among a large number of leading business executives and their organizations.

IMPACT ON ORGANIZATION

As a general proposition the responses of the executives interviewed were emphatic that computers and their related utilization were having only a very limited impact on general organizational structure. While in many situations major organizational changes had been and were being made, the belief was strongly expressed that such organizational actions were essentially attributable to considerations other than computers. These other considerations included competitive developments, operational performance, availabilities of people and their talents, technological developments, changing managerial philosophies, personal values. The point was frequently made by staff personnel that the top management people who initiate and direct organizational changes did not really

understand the computer developments, and hence could not be basing major organizational decisions upon computer considerations. In some situations, in fact, the computer personnel reported that they faced real problems adjusting to major organizational changes of which they had not been consulted or apprised in advance.

Generally, however, it appears that top management is aware of the "general" state of computer developments in the company but regards computers and the related applications as "operational backup" to support whatever type of organizational structure they, the managers, may elect. While they recognize that computers provide new capabilities which make it possible to cut through or otherwise modify existing intermediate organizational levels—as, for example, the new accessibility of operational data covering the several subordinate organizational levels—executives typically assert that they have no intention now to use such capabilities significantly to influence their organizational thinking. The reasons advanced are that there are other better uses of top managers' time and that, in any event, they cannot afford to undermine the motivation of lower level managers.

On the other hand, most executives would not go so far as to rule out future possibilities of the impact of computer developments on general organizational actions. This reflected a general uncertainty as to what might happen as a result of more experience and, as more understanding was acquired, of computer utilization. The responses did, however, clearly support the view that computers were currently not really a major force and that in the foreseeable future they would not be a major determinant in the formulation of decisions relating to organization structure. They anticipated a slower and more evolving type of influence as opposed to anything immediate or dramatic.

These findings were consistent with the further majority view that profit decentralization as a particular type of organizational approach would continue to be useful. Some executives felt even more strongly on this particular issue, describing their experience and continuing view that computers would make it possible to disentangle previously existing interrelationships and to provide the kind of operational data which would make possible the further extension of profit decentralization to new areas and in greater depth. Other executives stressed the belief that the use of computers would provide additional support to those in charge of profit centers and in that way make those organizational entities even more effective and stronger as operational components. A few executives suggested also that the new access potentials available to top management would serve as a healthy inducement to keep profit center managements more alert and thus actually more effective.

There were, however, some executives who were more cautious as to the ongoing importance of profit decentralization. They pointed out the new opportunities to look more analytically at interrelationships with and among profit centers, and to make plans and major operational decisions on a more

ver-all company interest basis. The result of such actions is to curtail the reedom of action of individual profit centers and to move to greater entralization at the headquarters level. A good example is found in the etroleum industry where the production and distribution of products can now e controlled more efficiently by optimization models which operate on a egional, and probably ultimately, on a total company basis. But even in this ituation, the new constraints are tempered in part by certain types of nter-profit center negotiation, and these constraints do not appear to be eriously undermining the feeling of responsibility for profit results. There seems o be recognition that the scope of profit center responsibilities is being hanged—and that they will be further changed—through the kind of central nalysis that computers now make possible, but that the continuing effectiveness nd vitality of profit centers as a type of business organization can and will be naintained despite the altered relationships.

To date, the findings were that computers have no significant impact upon the rganization of staff activities. In this area, there is, however, considerably more aution and more speculation on the part of company executives. In two nstances, particularly, the existing computer potentials demonstrate a possible ignificant impact for the future. One of these instances is related to the levelopment of growing central data banks. Where traditionally each staff has ended to develop separately the information pertinent to its particular staff ole, now the development of required information in the common data bank is roviding a single uniform and authoritative source. The result has been a ontraction of the individual staff groups. In several corporations the use of entral data banks has been given still greater importance by assigning this unction to an independent information services group, where it shows some vidence of emerging as an important staff group.

A second instance of significance is the merging in computerized information ystems of financial and operational data. This has had the effect of moving urrent accounting activities away from the previously existing separate channels n the finance group and transferring this function to the general information andling groups. In several corporations, the newly organized computerized nformation service has taken on responsibility for the current accounting ctivities. In these circumstances the finance group is supplied data on request or their analysis and use in their assigned staff efforts.

EXTENDED SYSTEMS

The development of computerized systems to date has been largely for nanufacturing and technical processing. In those areas, the organizational tructure has been modified to reflect the new work responsibilities and the new low of the work. Currently, however, one of the major frontiers of computer levelopments is the appearance of more extended systems which cover various

operational areas such as purchasing, inventory availability, and customer services, and further, in linking these individual operational areas into more extended systems. One of these extended systems, for example, links customer orders with order filling, inventory replacement and production needs. While the extension of these systems becomes increasingly difficult and while they may never cover the total operations of a business, they are expanding in scope of coverage. To the extent that such systems are in fact extended, the modification of organizational structure covers an increasing part of the total company. Because the system, as developed, calls for new work flows and new types of operational relationships, it seems clear that this is, in fact, a developing source of further change in general organizational structure.

The interviews and research provide important evidence of the unifying force of most types of computer applications, both in study and developmental activities and in the actual operational stage. The very act of using a computer requires a precision and order in the way of making data acceptable to the computer. It becomes necessary that data be uniform when drawn from the various parts of the company, and that they be handled in the same manner as a part of standard operational procedures. The impact extends throughout the company and affects in a significant manner—often for the first time—the various organizational components. It is this recognition of the need for precision which requires the broad study of the various computer applications which have general company coverage. The problem appears to be best dealt with through the creation of study teams in which the various operational and staff groups are represented to interpret and protect their different organizational needs. It is here that the findings increasingly demonstrate the unifying force—making the various organizational components more aware of the needs of other organizational components and knitting them together more in terms of total company interest. At the same time, these actions set the stage for actual organizational changes which may be more appropriate in the light of the changed operations which result from the new computerized systems or other operational applications.

When a particular operation is covered by a computer application, the findings are substantially as would be expected, namely that routine jobs previously done on a manual or other noncomputerized basis are eliminated partially or completely, and that the organizational responsibilities for the new computerized operation are realigned to fit the new types of responsibilities and the new flow of the work. In a situation where inventory records kept by hand are now placed on magnetic tape, it is quite natural to find the organizational structure of the affected departments simplified and the staff contracted to reflect the transfer of certain work to the computer. A large-scale example of the same type of change is the contraction and simplification of clerical work in handling airline reservations made possible by the new centralized computer systems. The exact scope of realignment in all such situations varies greatly and is necessarily

tailored to the specific situation. But it is a kind of organizational change which becomes reasonably clear and definite.

PERSONNEL PROBLEMS

In these operational applications, the scope of the reduction of personnel needs—both in the areas of clerical and supervisory personnel—varied considerably. In each case an inquiry as to nature and number of the personnel displacement disclosed that these problems had not been serious—despite frequent allegations in the literature to the contrary. The reasons advanced were mainly that the length of the period involved in the development and installation of the application provided sufficient time to train the excess personnel for transfer to other areas—including the computer operations themselves—and that this action, coupled with generally increased needs due to expanding volume of corporate operations and with normal attrition, reduced the problem to negligible proportions.

While the research did not contemplate a depth inquiry into the human reactions of individuals affected by the extension of the computer activities, the opportunity was again utilized to inquire, insofar as it was possible, about this aspect. As might be expected, individuals at all levels are sensitive to computer developments which impinge directly or indirectly upon their existing sphere of operations. These situations range from the prospective loss of a particular type of job to a partial loss of control over the job or responsibility. These are very real problems which the corporations have been compelled to recognize and deal with. In the general view, however, these motivation problems have been and can be handled satisfactorily. The general approach reported to be most effective was:

1 to provide early assurances that computer development would not be permitted to endanger personnel security or to curtail the employee's effectiveness, and
2 to stand back of these assurances as the program actually progressed.

Additionally there seemed to be good evidence that personnel once adjusted to the new operational relationship found their new situations as satisfying as the previously existing situation and in many cases even more so.[1]

Another important aspect of the organizational problem relates to the organization of the computer activities themselves.[2] Responsibility for the

[1]These findings are also consistent with the findings of Professor John Beckett as reported in "The Impact of Computers on Management," M.I.T. Press, pp. 219-233.

[2]This area was dealt with in more detail by the author in "Who Gets the Computer?" in the Fall 1966 issue of the *Columbia Journal of World Business.* The present discussion briefly updates that previous discussion. In general, the previous findings are further validated.

computer hardware—the basic computers, input and output devices, and major storage facilities—has been typically centralized. This may take the form of one organizational component providing computer services for another organizational component—usually at the same geographical location. At a more advanced stage, the centralization is accomplished on a more systematic and complete basis through regional centers, which then may be made independent of the organizational components they served. In some cases, there is an even greater consolidation of computer services at or near the corporate headquarters, and the existing regional centers are linked together for the shifting of work load as needed. There could conceivably be a single control computer center, but this development has thus far seemed to be practicable only in the case of a smaller corporation.

The technological capacity is now available to handle input and output through remote terminals, which when combined with decreasing communication costs and the availability of central equipment with greatly expanded capacity, makes it technically feasible to handle greater volumes of diversified computer work at centralized locations. These developments have made possible both greater operational efficiency and lower unit costs.

There are, however, some factors working in the opposite direction. Despite the development of the best standards of service by the central location, there are still certain operational control benefits in having one's own computer equipment at the individual field locations. For some kinds of systems applications—as, for example, manufacturing processes—this has been found to be essential. In other situations, there are technical users who need to interact more closely with computer equipment on site. In general, there is normally some psychological resistance from managers to the loss of control over specific computer equipment.

In planning the development of computer systems, we again find strong evidence of centralization, but in a manner which is more selective and significantly different in character. In the case of computer application where more than one organizational component is involved, and ranging up to total company application, it has been found to be desirable that the study of such applications be initiated and controlled by a centralized corporate group. Such actions are felt to be necessary in order that company interests can be effectively recognized and protected. On the other hand, there may be need to have development groups attached to organizational components when the scope of the operations of that component so justifies. This partial decentralization encourages the local management to study the contribution of computers to the solution of local problems and to assist in interpreting local needs in connection with the study of broader company applications. This decentralization of planning is made in many situations irrespective of the greater centralization of computer hardware.

Looking at computer activities as a whole, there is some evidence of actions and plans to bring together all the pieces of the computer job at a particular

cation. This has meant, for example, the grouping of the more scientific and perations research talent with other computer development personnel under e same organizational head. It has meant increasingly placing the responsibility r planning and the care of the hardware in the same organizational group—thus est protecting the close interrelationships which have to take place between ese activities. The combined groups have been placed at a higher organizational vel in the company and in a number of cases taken away from the traditional signment to the controller or other financial officer and given a more dependent status. It is asserted that this latter shift eliminates any possibility—hether real or imaginary—that the computer effort is being unduly focused on e older types of accounting and related clerical applications, or that the mputer effort is too much under the control of the finance group. More equently these new organizational groups are headed by a high-level corporate ecutive drawn either from the general managerial or scientific areas—as pposed to the earlier practice of having the group headed by an accounting man a computer technician.

We have endeavored to learn more about the relationship which exists between mputer developments and general organizational actions—particularly to certain whether computers are a significant determinant of current organiza-onal decisions and forward plans or, if not that, to determine the kind of lationship which actually does exist. The findings indicate a negligible impact n general organizational policy, a direct effect in the operational areas nmediately involved, and centralization trends in the organization of the mputer activities. Significant also is the firm indication that profit decentrali-ation as a major organizational policy will continue as a sound form of rganization for large corporations with diversified operations. At the same time, ere are certain areas where the influence of computers in the future might be ore significant. The indications are that the forces for centralization ngendered by the new computer capabilities are being counterbalanced by owerful opposing forces and that the trade-off between the two sets of forces ill be relatively gradual and evolutionary. The real role of computers is to help anagement executives organize and manage as they basically desire.

It is, of course, recognized that organizational decisions are but a part of the tal management function. Some of the more basic questions have to do with e impact of computers on general management practice. In this broader sense, ere seems to be little doubt but that computers and the related computer pplications will play an increasingly important role. This trend is clearly dicated both by the expanding range of computer applications currently under tive study by corporations and by the kind of organizational support being ccorded the computer activities. Especially encouraging is the greater personal volvement which is now developing on the part of top management executives s demonstrated by support of company-wide management educational pro-rams and through personal participation in the selection and development of ajor computer application projects. The latter is helping to bridge the

all-too-common gap which exists between management personnel and computer personnel and to interrelate more effectively computer capabilities with the currently existing management processes and problems. Reciprocally, computer personnel are doing more to understand management needs. They are learning how to rise above their own specialized vocabulary and more technical interests, and to communicate effectively with management personnel about management problems.

Managers of tomorrow will most certainly be more deeply involved in the active use of computers and related computer applications in carrying out their total management responsibilities. This will result in part from the greater knowledge possessed by the young men entering corporate life today. It is in this connection that the educational institutions—especially the professional business schools—have a special challenge to prepare their graduates in such a way that they can most effectively adjust to these new kinds of requirements and opportunities. The challenge to use the computer effectively together with its awesome capabilities for the more productive operation of corporations and thus the total welfare of society is a very real challenge. Here, indeed, is the future promise for all who are interested in business in its full professional sense.

READING 21 DISCUSSION QUESTIONS

1 Identify and discuss the forces which tend to oppose centralization of authority.

2 "The role of computers in organizational decisions is more supportive than causal." Discuss this statement.

3 Summarize the position taken by Professor Brink on the question of whether computers will lead to a greater centralization of authority.

4 What impact, if any, will broader (or "extended") systems have on an organization?

READING 22 HOW WILL TOTAL SYSTEMS AFFECT THE CORPORATION?*

DONALD L. CARUTH

Consider the following definition: *The* total systems concept *is an approach that visualizes the business organization as a single entity composed of various*

*Reprinted from the *Journal of Systems Management*, pp. 10-13, February, 1969. Reprinted by permission from the Association for Systems Management, 14587 Bagley Road, Cleveland, Ohio. Donald L. Caruth is an instructor at North Texas State University.

interrelated and interdependent subsystems working together to provide timely and accurate information for management decision making, which leads to the optimization of overall enterprise goals.

Certainly such an approach represents a new way of conceptualizing and managing business organizations. This article will speculate on the organizational impact of the total systems concept.

Such an evaluation is difficult because the changes affecting organizations in the future will result from several factors, such as economic growth, technological advancement, and changing managerial concepts. The primary cause of these changes will not be the total systems concept alone; rather, a combination of several forces, of which the total systems concept is a part, will accelerate the evolutionary process.[1] In addition to this complication, there is the problem of attempting to evaluate future trends on the basis of limited past experience with the systems concept.

Despite the difficulties, however, an evaluation must be attempted, for the concept will have a substantial and widespread impact on organizations. Its impact will be felt by employees as well as managers as it manifests itself in new organizational arrangements and operational procedures.

Because the total systems concept cannot be separated realistically from the device that makes its implementation technically and economically feasible, the following assessment of the concept's impact assumes the essentiality of a computer in a total system.

IMPACT ON MANAGEMENT

Systemation, the implementation of the systems concept, has been described as "the thinking man's revolution." Certainly, systemation is an unusual revolution. For the first time in industrial history, those most affected by the change are also those responsible for initiating and planning it. This means that the brunt of the impact of the total systems concept will be borne by managerial levels. Those changes that occur at the top of the organizational hierarchy will be of great importance because they will be responsible for other changes throughout the organization.

EXECUTIVE-LEVEL MANAGEMENT

Some experts, according to one writer, believe that in the year 1985, a manager, sitting in a "paperless, peopleless office," will make decisions based on information and analyses flashed on his own cathode ray tube.[2] Other writers

[1] Richard A. Johnson, Fremont E. Kast, and James E. Rosenzweig, *The Theory and Management of Systems,* New York, McGraw-Hill Book Company, 1967, p. 405.

[2] John Dearden, "Myth of Real-Time Management Information," *Harvard Business Review,* XLIV, May-June 1966, p. 131.

see essentially the same thing coming to pass much earlier. Regardless of whether he sits behind a computer terminal or not, the top executive in the systems age will find that his decision-making activity is considerably different from what it is today.

As operations become more systematized and integrated, they become increasingly self-operative because of "predecisions." As this happens, systems tend to manage themselves and there is less need for intervention on the part of human managers. The result is that the focus of executive-level decision-making moves farther and farther into the future. Freed from the numerous short-run decisions he must now make, tomorrow's executive will be better able to concentrate on longer-range planning. He will have less excuse to let today's emergencies steal time that should be allocated to planning for the future.[3]

Executivies will be able to make decisions faster because cycle time will be shortened. One of today's problems is the decision-making time lag created by the necessity of getting facts up through the corporate hierarchy to top management and then getting management's orders back down the hierarchy. The truly total system will provide management with information in real-time. Decisions can be made and orders fed into the system within a very short time span.

But not all decisions can be or will be programmed. In the upper echelons, judgemental factors in major decisions will remain substantial and often dominant. There will be an increased emphasis on exploring courses of action and selecting from alternatives. As a result, the systems-age manager will need to be more creative.

Although the implementation of the total systems concept will undoubtedly reduce the need for many top executives, their ranks will not be decimated to the same extent as the ranks of middle managers. In fact, a recent report by the American Foundation on Automation and Employment stated that the use of computers in management functions has not directly caused *any* executive unemployment. With total systems still in their infancy, one would not yet expect to see a decrease in the number of executives. But the future may well tell another story.

MIDDLE MANAGEMENT

Among the hardest hit by the implementation of total systems will be middle management. Already, widespread use of the computer for automating operating subsystems has had a significant impact. For example, Metropolitan Life Insurance Company has experienced a 75 percent increase in volume of business

[3] Herbert A. Simon, "The Corporation: Will It Be Managed by Machines?" in *Management and Corporations 1985,* New York, McGraw-Hill Book Company, Inc., 1960, p. 51.

since 1954 when the company installed its first computer. In the face of this increase in business, there has hardly been an increase in the middle management ranks of the firm. Or take the case of Gulf Oil Company: it employs no more middle managers today than it did a decade ago. Because these examples reflect only the effect of computerization and systemation of subsystems, it can be speculated that when all operating subsystems are integrated into one "total system," the effect on middle managers will be even greater.

Traditionally, the function of middle managers has been to make operating decisions, to gather information for top management, and to implement the policy decisions of top management. In effect, middle management has served as a buffer between top management and operating employees and first-line supervisors. The power of middle management has often been the "power of knowledge."

Linking an organization's subsystems into one overall system with a computer at the center of the total system means that many decisions now made by human managers will become programmed decisions capable of being performed by the computer. This will eliminate the need for middle managers to spend much time or thought in making decisions. As a result, both the number of intermediate management levels and their relative influence will shrink.[4] Not only will this result in a reorganization of middle management levels, but also in a downward shift in status and compensation. John Beckett describes the middle manager's fate this way: "As systemation advances, operating managers tend to metamorphose into monitors, and decision making moves upstairs."[5] And since the number of middle managers is to some extent a function of the number and kind of decisions made, fewer managers will be required with the implementation of a total system.

The authority of knowledge that middle managers derive from their familiarization with operations will also be damaged because a total system will give top management the ability to control operations and make more effective decisions since pertinent facts will be available as fast as they occur. Thus top management will be able to occupy a position much closer to daily business events, relying upon the computer to gather and process large amounts of data regarding the business and its environment and to create meaningful analyses and reliable forecasts from the accumulated data. No longer will it be necessary for intermediate managerial levels to collect data, screen it, embellish it, and pass it on to top management. All information needed by top management will be

[4] Raymond A. Ehrle, "Implications of a Systems Approach to Organizations and Management," *Personnel Journal,* XLIV, February 1965, p. 79.

[5] John A. Beckett, "Management, Motivation, and Management Information Systems," *Advanced Management Journal,* XXX, January 1965, p. 69.

stored in large corporate data banks that can, on short notice, respond directly to questions from top management. The power the middle manager once derived from his knowledge of operations will thus be eroded away, for now this formerly private knowledge will be available on a broad scale.

Not everyone agrees that the systems concept will drastically reduce the ranks of middle management. William Crowley observes that we have not yet reached the point where electronic data processing systems can perform all the low-level duties required of them, yet prognosticators are doing away with middle management. Crowley points out that Taylor's emphasis on management by exception and increased office mechanization were earlier forces that supposedly would eliminate middle management. And now with the advent of the systems concept, for the third time in the 20th century, middle management becomes obsolete.

Crowley feels that the total integrated system is in reality a limited system. It gives the top executive a clearer, more timely picture of what he already knows. Managers will still be needed to make decisions on all the unanswerable questions of environmental factors.[6]

Another dissenter is Peter Drucker, who feels that the computer will not reduce very much the number of middle managers. Computerization and systemation, he feels, will instead restructure middle management jobs, organize work on a more logical basis, and free middle managers for more important jobs. The ranks of the decision makers will not decrease, but instead more people will have decision authority because more people will be able to get the information needed for making decisions.

The dissenters appear to be few. Most writers agree that the systems concept and its hardware heart, the computer, will reduce, both in number and importance, middle management jobs.

MANAGEMENT SKILLS

As the process of management evolves from an art to more of a science, profound changes will occur. One of the most significant will be in the area of training for management. The changes in required skills would seem to be the result of an accelerating science and technology. However, the total systems concept does play a part, because its successful implementation requires a reorientation of management thinking as well as a basic understanding of systems concepts and tools.

As the role of the manager evolves in the new environment of total systems he

[6]William J. Crowley, "Can We Integrate Systems Without Integrating Management?," *Journal of Data Management,* IV, August 1966, p. 15.

will need to know more about systems engineering, and a large part of his job will have a strong systems flavor. In order to function in this environment, it isn't necessary for the manager to become a mathematician, an operations research specialist, a programmer or a systems analyst. But he must be able to communicate with such people. He must know what the computer can do and what operations research can do.

In a sense, the manager of the future will be a management scientist, oriented to the systems approach. Forced to think in terms of systems and quantitative approaches, the manager of the future will be different from today's manager. Tomorrow's middle manager should have a bachelor's degree in engineering or science and a master's degree in business administration. In addition, he must possess a knowledge of the behavioral sciences as well as statistics and computers.[7]

Not only will the total systems concept require tomorrow's managers to be more quantitative, but it will require them to be more decisive also. The total system with its on-line real-time computer complex will provide vital information almost instantaneously to the manager. Strategic and tactical decisions based on these data will have to be made more quickly. Thus, managers will have to think harder and more precisely to take advantage of this information.

The manager in the systems age will spend more time educating himself and keeping up to date in new developments. Already discernible is a shift in emphasis in management development programs. In the 1950's, the emphasis was directed to improving interpersonal relations. This emphasis began to shift in the 1960's toward improving technical knowledge and proficiency. Undoubtedly, this trend will continue.

At the employee level of the organization, the implementation of a total system will probably: (1) create new jobs for some, (2) eliminate many present jobs, and (3) result in some degree of depersonalization.

In the short run at least, the systems concept will create a need for systems analysts and computer programmers. At the present time there are more than 100,000 computer programmers. By 1970, 200,000 will be needed, according to estimates. In addition to programmers, computer operators will also be required. Even though the systems concept will create some jobs, in comparison to the total labor force the number will be small. And, according to one authority, there is some reason to believe that the number of technical and skilled jobs like those of computer programmer or operator is not increasing as rapidly as the labor force as a whole.[8]

[7] George Berkwitt, "Middle Managers vs the Computer," *Duns Review and Modern Industry,* LXXVIII, November 1966, p. 109.

[8] Ida Russakoff Hoos, *Automation in the Office,* Washington, D. C., Public Affairs Press, 1961, p. 123.

Rather than creating jobs, the systems concept will display a tendency to eliminate jobs. For example, when Westinghouse installed a new order system utilizing a computer and data communications, it was able to close six warehouses. And this is just the result of integrating the parts of one subsystem.

As company subsystems are integrated into a total system, the computer, because of its ability to take over routine, repetitive clerical tasks, will absorb many of the jobs now being performed by people. Thus, it is likely that a diminution in the number of clerical job opportunities will occur. The office of the future will resemble the factory in that a small group of employees will operate a large computer complex just as in the factory a small number of workers will operate an automated manufacturing system.

Not everyone agrees that the computer and the systems concept are eliminating jobs. According to some authorities, there doesn't seem to be any evidence at present that computers are eliminating either operative employees or managers. Oliver W. Tuthill, president of Illinois Bell Telephone Company, citing his own firm's experience, feels that substituting computers for clerks has not caused wholesale job displacement, although such action has slowed down the rate of expansion in clerical positions.[9] Tuthill goes on to point out that his organization first computerized high-volume clerical jobs in the 1950's. At the present time, most clerical activities are mechanized to some extent. But, despite the increase in computerization, over the past decade the number of clerical jobs has increased from 90,000 to 115,000.

Another effect of the implementation of total systems will be depersonalization, which will result from the demands of the system for more conformity. A study reported in the *Journal of Industrial Engineering* indicates that electronic data processing systems may significantly reduce employee feelings of worth and power. As the machine becomes largely responsible for the quantity and accuracy of work, the employee feels deprived of his responsibility for producing a product. He becomes depersonalized because he no longer has control over the outcome of his work.

The consequences of depersonalization may be increased resistance to change, increased turnover and, in general, damaged morale. But systems may not necessarily lead to morale and motivation problems since employees may experience great satisfaction from the teamwork that the development of more rigid systems forces upon them.[10] Whether this will offset forces of depersonalization remains to be seen.

Foremost among changes in the corporate structure will be a trend toward recentralization.

[9]Oliver W. Tuthill, "The Thrust of Information Technology on Management," *Financial Executive,* XXXIVV, January 1966, p. 22.
[10]Beckett, *op. cit.,* p. 73.

Structuring an organization according to the systems concept does not eliminate the need for the basic functions of planning, organizing, directing, and controlling; structuring an organization according to the systems concept does, however, emphasize interrelationships of parts and segments and integration of activities. This is something traditional organization theory, with its breakdown of business organizations into artificial functional areas, does not emphasize.

Functional decentralization in the past was an outgrowth of the increase in size and complexity of organizations. As firms grew it became impossible for one man or a small group of men to run them. Therefore, top managers arranged their organizations functionally, and delegated authority to divisional managers. One of the fundamental reasons for such decentralization was that the science of collecting and reporting information was not far enough advanced. The top manager had no way of knowing if he had all the information necessary to make a decision. Thus, decision authority was delegated to the points at which information was collected. But decentralization was a mixed blessing because it tended to multiply jobs, duplicate functions, establish local goals not in line with organizational goals, and place strain on the information system by multiplying the need for information.

The total systems concept will eliminate traditional decentralization and its associated problems. This will be possible because we will possess the technology to build information systems transcending the necessity for compartmentalized arrangements based on functional specializations.[11] On-line, real-time systems make it possible, as pointed out earlier, for top management to have vital information instantly available. Thus, there is a growing tendency for decision making to recentralize itself in the hands of top management.

Recentralization means that the organization shape will change considerably. Some experts see tomorrow's organization in the shape of an hourglass, a two-layer structure with executive management above, line management below, and few functions in between.[12] A survey of 300 top executives indicated that they felt the present organization chart would be replaced by a flattened version. However they visualize the future organization structure, most experts agree that the present-day pyramid will become outmoded as functions change and departmental lines collapse.[13]

CONCLUSIONS

Although not totally responsible, the total systems concept will play a significant role in reshaping organizations. The already observable trend toward

[11] Tuthill, *op. cit.,* p. 26.
[12] "How Computers Will Reshape Management Team," *Steel,* CLVI, January 1965, p. 47.
[13] Hoos, *op. cit.,* p. 90.

recentralization will accelerate, shifting power back to top management and reducing the need for middle managers. Implementation of a total system will lead to increased worker depersonalization. As computers absorb all routine work and much of the decision making now done by humans, the worker will feel less responsibility for what is produced and will derive less satisfaction from his work. Therefore, one of the key problems of the systems age will be the development of effective, man-machine systems that not only achieve corporate goals, but also provide job satisfaction for their operators. As the educational level of the work force rises, this problem will become more critical.

READING 22 DISCUSSION QUESTIONS

1 Summarize the position taken by Mr. Caruth on the question of whether computers will lead to a greater centralization of authority.
2 (a) What effect will computers have on middle managers?
   (b) On nonsupervisory employees?
3 How will anticipated systems development affect the skills needed by managers?

READING 23 MIDDLE MANAGERS vs. THE COMPUTER*

GEORGE BERKWITT

"The trouble with a good many managers is that they cannot appreciate something new. They just will not adapt to the new sciences." So said Frank H. Hawthorne, at the time manager of management services for the industrial division of Honeywell, and now a systems specialist for General Electric.

The "something new" to which Hawthorne referred was that omnipresent twentieth century phenomenon, the computer. And the specific target of his criticism was a top marketing executive with whom he had spent eight hours painstakingly reviewing simple mathematics. "You might think," said Hawthorne with more than a trace of bitterness, "that he would have been prepared with enough simple math to at least recognize some of the computer's potential for solving marketing problems. But he wasn't. Unfortunately, his ostrich attitude is all too typical of today's middle manager."

Hawthorne's is one of a growing chorus of voices that are expressing disenchantment these days over industry's largely unimaginative, and surprising-

*Reprinted from *Dun's Review,* pp. 40-42ff., November, 1966. Reprinted by permission from *Dun's Review,* New York. Mr. Berkwitt is a staff writer with *Dun's Review.*

negative, response to the challenge of the tireless robot brain. The fact is that ehind the closed doors of the business world, a silent but nonetheless bitter attle is being waged. It is not too much to say that today's middle manager is oo often tense, worried, and trying by almost any means at his disposal—in a ew cases, actual sabotage—to short-circuit the electronic newcomer. In trying to reserve at all costs a comfortable status quo, he is foolishly creating internal roblems so knotty for many a company that top executives think they may ke years to solve.

The typical middle manager appears to take little comfort from the declaration y one social sicentist that he is hardly fated "to go the way of the dinosaur." or does he derive any real sense of security from all the evidence that the utomatic office or plant, run with brisk efficiency with only one or two human verseers, still lies in the remote realm of science fiction.

In his apprehensive state, the middle-management man is easy prey for the reachers of doom. He forgets too readily how vital are his own technical and dministrative skills in the overall scheme of things, even in the brave new world f electronic science. After all, the computer, modern marvel though it is, epends for its ultimate success on acceptance by second- and third-echelon xecutives. As Chairman George Spatta of Clark Equipment Co. puts it: "If the iddle manager does his job well, his company is in a position to make money nd grow. If he doesn't, his company is in trouble. It's as simple as that."

Yet so unnerved are many such men by the chill prospect of being supplanted y a bloodless machine that they ignore those reassuring words. Overlooked, oo, is the cheerful conclusion of Milton Uscher, assistant comptroller of ethods research at Lever Brothers Co. "If they were good at their jobs before e computer," says Uscher, "its arrival on the scene will do nothing to make em obsolete."

Now just what are the difficulties that this cold war has sparked? Among the ost serious, say close observers, are a painful slowdown in corporate progress uring the crucial phasing-in period, disrupted transfer of data among various vels of management, dissension in the lower ranks, and operational headaches nging from erratic forecasts to expensive lags in the very programs the omputer is supposed to help accelerate.

Top management, needless to say, is eager to root out all such inefficiencies. ut more often than not, its attempts to do so are frustrated because resistance the computer is so deep-rooted psychologically among middle managers that onventional techniques for solving personnel problems are of little avail. omplains one disgruntled systems manager: "Management never faced a ougher challenge. You can buy the best computerized system in the world; but the managers who have to use it don't want it, it will fail and you'll never now why."

Systems specialists are quick to note that while cause and effect in a given omputer-manager impasse can be devilishly elusive, the cause, at least, usually

falls under one of the following heads: resentment, fear, anger, stubbornness, ignorance, rigidity, mistrust or plain incompetence. This conclusion is bolstered by a report released earlier this year by the American Foundation on Automation and Employment. Interviews wtih educators, businessmen and government spokesmen persuaded AFAE that the principal causes of management antagonism were "concern about personal adaptability to a mechanized system, uncertainty as to their roles in it, or fear of losing status as supervisors of large numbers of skilled workers."

Introspection, one must admit, is neither a daily requirement nor a regular practice in the life of a middle manager. Consequently, he may be the last to understand why he reacts to computers as belligerently as he does. If anyone is likely to know the answer, though, it is the systems specialist who is called in for consultation.

In a fairly typical case, the specialist firm of H. B. Maynard & Co. of Pittsburgh was asked to study procedures in a plant that had installed a computerized accounting system a year before without achieving the expected increase in efficiency. Its investigation showed that the payroll supervisor was insisting that his clerks recalculate the pay of the company's 1,000 hourly workers after each payroll had been completed by the IBM 1401.

Maynard's crew discovered a programming defect and a fault in auditing. But they also found that neither of these troubles justified the extra work. Eventually, the supervisor confessed to two contrary emotions: a lack of faith in the machine and apprehension that it might jeopardize his own status. "The recalculation," in the view of Joseph H. Redding, manager of Maynard's management sciences division, "was a rather costly and insidious resistance to the whole computer operation."

On the highly automated Pennsylvania Railroad, an enlightened approach has straightened out most of the computer-manager problems. With six computer centers and an annual tab for equipment rental of over $2 million, the Pennsy vies with its proposed partner, the New York Central, as the nation's most highly computerized railroad. But bitter memories of the switchover to the computer linger on. Recalls George A. Kessler, Pennsy manager of Data Center Services: "Supervisors didn't think the computer could solve problems then being handled by people. They were operating in regional data centers and didn't want to give anything up to the new central system. They even refused to let go of a lot of plain drudgery."

Other companies beset by similar problems have run into even more trouble. From those interviewed by AFAE came a battery of specific complaints. A railroad official noted constant delaying tactics: "Information that we should get currently is received next week." A cosmetics manufacturer uncovered actual sabotage, necessitating special central-office audits of field procedures. And one company found that "some employees will deliberately design a form that will not conform to what we require." Such monkey-wrench responses to the advent

of the computer are far from rare. Says one executive wryly of his recalcitrant managers: "They embarrass you in a safe way."

Keith French, chief of research for the South Carolina State Development Board, suggests that such a hostile attitude may result in "a kind of perpetual evaluation and investigation of a program, which seldom, if ever, is consummated unless pressure is brought to bear by top management." When this type of foot-dragging is multiplied by the 35,000 computer systems now operating from coast to coast, the possible aggregate losses in time, effort and computer payout become staggeringly high.

How, then, can top management calm the fears and curb the resentments of the middle-executive ranks? The question is not easily answered.

The use of computers in management functions has not, according to the AFAE report, directly caused any executive unemployment. But it adds ominously: "Automation has already cut deeply into the need for middle managers."

Even now, the rise in the number of such men is lagging far behind the rate of U.S. corporate growth. At Metropolitan Life, for example, the volume of business has soared 75% since the company installed its first computer in 1954, but the ranks of middle management have increased hardly at all. Even more dramatically, Gulf Oil, despite a steady corporate expansion, employs no more middle managers today than it did ten years ago, and has actually reduced its credit evaluation staff by an estimated 25%.

For better or for worse, then, middle management faces a stern ultimatum to adapt. Top executives customarily show little patience with anything that gets in the way of corporate performance. Thus increasing signs of discontent and resistance in the ranks of middle managers are likely to speed rather than delay the adoption of the computer in company operations.

LITTLE HELP FROM THE TOP

Ideally, to adapt to the mounting demands of the electronic age, each manager should go through a careful process of self-examination and, if necessary, indoctrination. So far, as noted, he has had little help along this line from the top echelons. (None of the companies surveyed by AFAE boasted a formal program "to retain and upgrade the skills of their senior managerial cadre.") So much brainpower is being concentrated on the dilemma of the blue collar worker in an automated society and on management's own problems of adjustment that the middle manager has become almost a forgotten man.

Until his dilemma receives more sympathetic attention from educators, government and business itself, the middle manager will be left largely to his own resources. And while the computer clicks merrily and efficiently on, he will be fighting back with only the most primitive (and self-destructive) of weapons: emotion and inertia.

The most critical period in the life of the middle manager is during the phasing-in of the computer. At that time, he faces a starkly new situation in which his years of experience, his painfully acquired know-how and his personal relationships with top management seem to no longer apply.

A typical example of the chaos that may then confront him is cited by Edmund D. Dwyer, acting assistant commissioner for Automated Data Management Services for the General Services Administration. He gives the following case history: "The computer was installed in a facility where it could be shared by many different functions. It was not under the operational control of the middle manager. Time schedules, accuracy and programming of details for the computer were all someone else's responsibility: yet the final results for the middle manager's own function were returned to him for his blessing before release to a customer or to another function. Any errors or discrepancies noted were difficult to have corrected and their causes were obscure. Initial installation troubles in the computer areas made schedules there too flexible, and this in turn upset the routines established back in the middle manager's area. Sometimes it was not made clear who was responsible for what. Events not previously anticipated in the procedures frequently became mountains instead of molehills."

This tale of woe points up some of the basic reasons for the middle manager's attempt to hold back the electronic tide: fear of losing certain responsibilities, status or even his job: fear of having to learn new routines; resentment of management's "cold-bloodedness" in forcing the change and of new guidelines and the bright young men who administer them. Too, he is worried about losing the carefully built up rapport with his superiors, resents being prodded out of a comfortable berth, and fears that his own shortcomings will be exposed.

The point is, of course, that middle managers, from vice presidents down to department heads, have always been rugged individualists within their own spheres of authority. The success of their operations, in plant or office, has depended ultimately on them. Traditionally, they have combined technical proficiency in their own specialty with the ability to carry out top management's directives efficiently and to communicate easily with people at all levels of the organization.

Moreover, they have always enjoyed a wide range of prerogatives. For example, their communications with top management are usually based on fairly casual standards of protocol. Their output is more often than not determined by limits that they themselves impose. And their ascendancy in the managerial hierarchy frequently depends on the number of people they are assigned to supervise.

But today many of those familiar standards are changing. The magic phrase now is "total systems." Whole businesses are planned as single entities, with all elements, including management responsibilities, coordinated. And the computer, its electronic tentacles reaching from inventory control to customer billing and from production to research, is making the system a working reality.

OPERATING BY THE BOOK

Under these conditions, the old conditioned responses and habits no longer apply. Industry generally is moving toward inviolable standards of performance and output. Managers, from top to bottom, must operate largely by the book. Decisions, programmed with the inhuman efficiency of the computer, are far more mechanical than they used to be. And the middle manager must deal with a greater variety of information, requiring more rigorous analysis and decision-making.

The severity of the challenge is pointed up by Leonard F. Vogt, general merchandise manager of International Shoe Co. "Middle management," he points out, "is employed basically in making operating decisions that implement the policy decisions of top management. In many of these operating areas, the computer can make decisions on a more timely basis, more accurately and certainly more consistently than men." Adds Vogt: "In my opinion, at least 80% of middle-management decisions ultimately will be computer-made." While he sees no immediate threat to the man in the gray flannel suit, his words are scarcely reassuring.

Nor is there much comfort for the middle manager, or the aspirant for his job, in the AFAE's description of the man he must become if he hopes to survive the competition of the electronic monster: "The manager with foresight, intelligence, courage, willingness to accept responsibility and familiarity with all phases of the enterprise apparently will not be made obsolete, either by the computer or by the technician who knows only how to program and operate it, if he is prepared to utilize these traditional qualities in a radically different context." Unfortunately, few of today's middle managers feel that they are blessed with such sterling qualities—or even with the ability to acquire them.

The computer thus becomes an inviting target for middle managers brought face to face with their own inadequacies. The latter, according to GE's Frank Hawthorne, can be appalling. "My job exists," asserts Hawthorne, "because sometimes the middle manager just doesn't know enough. He's flexible and knowledgeable when he's making his own decisions. But he has a long way to go to appreciate the new decision-making sciences and to recognize the computer's ability to help him.

To a manager who is not systems-oriented, the leap to a computerized way of doing business looks enormous. "It's like an ordinary person trying to outdistance a well-trained runner," observes President John H. Lippincott of Mauchly-Lippincott, Inc. in Fort Washington, Pennsylvania. "He is badly out of condition both in attitudes and in know-how."

In condition or not, Richard O. Baily, vice president of marketing for Burroughs Corp., for one, feels that the middle manager from now on will be under growing pressure to think in terms of systems. This trend, he asserts, will force those "now possessing the technical background to become more oriented toward an understanding of the whole firm."

As every executive knows, understanding corporate objectives, let alone achieving them, can be a pretty stiff challenge in itself. Yet as middle managers are increasingly held responsible for more of this kind of understanding, they are being given yet one more reason for resisting the computer; namely, the necessity for relearning. Specialists who have achieved some job tenure and whose diplomas are now gathering dust often show a surprising reluctance to go back to school. To some, the sight of one of their number taking courses is a cause for derision.

Maintains Louis R. Hague, director of business systems for Westinghouse: "The middle manager of the future should have an engineering degree or a degree in the physical sicences and a master's degree in business administration. He probably should know something about statistical analysis and the capabilities and limitations of computers and systems design and something about behavioral science."

Faced with this stiff curriculum, a few lucky managers have gained an edge—or at least a respite—when their companies have decided to move slowly into the strange new world of computers. Aluminum Co. of America is one example. Theodore H. Kerry, corporate assistant controller and president of Alcoa Management Information Service, explains that the major reason for Alcoa's delay in phasing into a computerized system was that top management thought it wiser to "work out the concept slowly, one plant at a time, rather than create chaos everywhere by going all the way at once."

AN INEXORABLE PRESSURE

But whatever his company's policy, the manager faces one pressure that simply won't wait: the progress of the computer itself. Every day, somewhere in America, new ways of exploiting its incomparable abilities are developed. For the hard-pressed manager, keeping up with technical advances alone is, in the trenchant words of one specialist, "a race between obsolescence and the grave."

Currently holding the spotlight are such innovations as time sharing (scheduling a computer so as to minimize its idle moments), new computer languages (codes) to aid in speedy scanning, liquid- or air-powered computer elements, and billionth-of-a-second responses. Those close to the technological front suspect that there are many other innovations (use of the laser, for example) not even being talked about as yet.

One of the most significant advances is the so-called utility concept, which allows any number of terminals many miles apart to be hooked into a common computer. Its implications for the future make today's middle-management problems look puny indeed. For with such a vast linkup, managers will have to wrestle with data pouring in constantly from distant offices and plants. Sales information from across the country will be in hands of top management in

hours instead of days. Inventory control will be nationwide and instantaneous.

The supreme irony of the middle manager's position in relation to the computer is sharply pointed up by Thomas L. Whisler, professor of industrial relations at the University of Chicago's Graduate School of Business, who says: "For the first time in industrial history, those who will be most affected by a technological change are also those responsible for initiating and planning it."

The position of the middle manager, then, is an ambivalent one. But the inescapable conclusion is that in the age that is now dawning, neither the middle manager nor the computer can get along without the other. Neither, it is safe to say, is headed for extinction. It remains for the enlightened executive to upgrade his own abilities to meet today's sterner challenge. Then he will be in a better position to work out some form of peaceful—and hopefully prosperous—coexistence with his electronic rival.

READING 23 DISCUSSION QUESTIONS

1 Why have middle managers resisted the change to electronic information processing?

2 What examples could be used to support the statement that "automation has already cut deeply into the need for middle managers?"

3 "The position of the middle manager is an ambivalent one." Discuss this statement.

SUMMARY OF CHAPTER 5

In Chapter 5, and in the readings included in it, we have looked at the present and potential consequences of computers on managers and on the environment in which managers work. We have seen that the data-processing activities of a business may be centralized or decentralized; we have seen that the computer can be established in one of several locations; we have looked at the composition of the computer department; and we have examined the computer's impact (1) on future organization and (2) on those managers who occupy positions in that organization.

A number of variables must be considered by each business before it decides whether to centralize or decentralize data-processing activities. The present trend, however, is toward the creation of centralized computer centers in the interest of reducing operating costs. Each firm must also decide where in the organizational structure the computer department should be located. A location within the finance function is currently the most popular; however, for many companies a preferable alternative might be to create an independent department. Regardless of the organizational location, the department itself usually

consists of systems-analysis, program-preparation, and computer-operations sections. An operations-research staff may also be included.

The effects which computers will have on the centralization or decentralization of managerial authority is unresolved. Thus far, the computer has supported a change in either direction. But speculation and controversy surround the unanswered question of what will happen to authority delegation when more sophisticated computer uses are perfected. Will any trends then be discernible? And, if so, what will the direction be?

Answers to these questions will obviously affect the future of managers at all levels. For the foreseeable future, it seems fair to conclude that middle managers will function in a setting which will become more challenging, more demanding, and more competitive.

STAFFING FOR COMPUTERS

There are a bewildering number of tasks—involving both technical and personnel issues—which must be performed concurrently in the many months between the time a decision is made to order a computer and the time the conversion to electronic data processing is completed. You will recall that in Chapter 4 we looked at the technical conversion steps which must be taken to develop and install new electronic systems. Before these technical matters can be concluded in a way which will satisfactorily achieve company goals, however, serious attention must also be given to personnel considerations. More specifically, plans must be made (1) to *select employees for new jobs,* (2) to *train selected employees,* (3) to *reduce employee resistance to changes,* and (4) to *alleviate hardships caused by job displacement.*

SELECTING EMPLOYEES FOR NEW JOBS

A most important aspect of staffing for computers is, of course, to select capable people to fill the new data-processing jobs. After all, the quality of the information systems which are developed is directly dependent upon this staffing effort. It is possible to classify the new positions created into the following occupational categories: (1) *data-processing management,* (2) *systems analysis and design,* (3) *program preparation,* and (4) *computer operation.* After a brief description of each of these job categories, we shall look in this section at the *recruitment of job candidates* and the *selection procedures* which may be used.[1]

DATA-PROCESSING MANAGEMENT

It is particularly important that a competent data-processing manager be appointed. This manager—like all managers—must perform the management

[1] A good presentation of the personnel management process at it relates to data processing is given by Dick Brandon in the article at the end of this chapter entitled "Personnel Management—Missing Link in Data Processing."

functions of planning, organizing, staffing, and controlling. He must plan the activities of his department so that it provides a quality, timely, and economical product. Careful *planning* is required to schedule installation activities and to provide the basis for control of the project. To be able to plan effectively and then *control* the activities of his department, the manager should possess technical competence in addition to managerial ability. But too much emphasis on technical competence at the expense of managerial ability should be avoided. Too often in the past, the most skilled technician became the manager only to demonstrate, very soon, incompetence in the techniques of management. (At the present time, in fact, data-processing activities are not well managed in a surprisingly large number of cases!) The manager selected should understand the company's business, its purpose and goals, and its data-processing procedures; he should be able to motivate people; and he should possess the poise, stature, and maturity to command the respect of other company executives as well as data-processing employees.

The data-processing manager must *organize* the human and physical resources of his department to achieve company objectives in a smooth and efficient manner. He must *staff* his department by selecting and then training competent employees, he must encourage these employees to keep up with rapid new developments occurring in their specialties, he should develop quantity and quality job-evaluation standards for control purposes,[2] and he must attempt to motivate and retain good employees.

Increasingly, people planning to seek a career in data-processing management must first acquire a college degree. Courses in business adminstration, economics, data processing, and statistics are desirable. If a company has a manager with the proper qualifications, or if it has a systems analyst with demonstrated managerial ability, it is fortunate; if it does not have such a person (and if it is felt that no present manager should be trained to take the job), it will have to be willing to overcome spirited competition in order to hire one from outside the organization. If one *is* hired from outside, he should be brought in far enough in advance to learn the business and to gain the respect of other managers before the conversion begins.

SYSTEMS ANALYSIS AND DESIGN

Although there is no generally accepted job description for the position of *systems analyst,* the job basically consists of (1) gathering facts about and analyzing the basic methods and procedures of current business systems; (2) determining company information needs; and (3) modifying, redesigning, and integrating these existing procedures into new systems specifications as required

[2] In his article, Dick Brandon notes that the average data-processing manager has not been aware of details such as these which are involved in good personnel management.

to provide the needed information. In addition to making the most effective use of existing data-processing equipment, the analyst may also (as in the case of the feasibility study) recommend justifiable equipment changes.

The systems analyst must be familiar with the specific firm—he must know its objectives, its personnel, its products and services, its industry, and its special problems. Also, he must know the uses and limitations of computers as well as other types of data-processing equipment, for he is the interpreter between managers and data-processing specialists. He must understand programming basics; he must be able to determine which jobs are candidates for computer processing; he must have logical reasoning ability; he must have initiative and the ability to plan and organize his work, since he will frequently be working on his own without much direct supervision; and he must be able to communicate with and secure the cooperation of operating employees and supervisors.

Educational backgrounds vary, but a college degree or the equivalent is generally desired. Courses which have proven valuable to the types of systems analysts described above are the same ones mentioned for data-processing managers. An analyst with a good grounding in management techniques is often a prime candidate for promotion to more responsible management positions both in and out of data processing because of his broad knowledge of the business. As we saw in Chapter 2, there is a severe and worsening shortage of qualified analysts.

PROGRAM PREPARATION

To summarize briefly, the job of the typical company *programmer* (as defined in this book) is to take the broad systems designs of the analysts and transform these specifications into workable, coded machine instructions. However, there are different programmer categories, and their duties vary in different organizations. In some companies, for example, a person with the title of "programmer" may perform *both* the systems-analysis and programming functions.[3] In other firms, a programmer may carry the work from the broad systems specification stage through the program flowcharting stage and then turn the task of writing the actual machine instructions over to a *coder.*

Because programmer job descriptions vary, there are also varying opinions about the educational background required of business programmers. Such

[3] The degree of separation of systems analysis and programming has depended upon the size and complexity of the company and its data-processing systems, the ability of data-processing personnel, and the desire of high-level executives to reduce communication problems and fix responsibility for each application on a single person. The lack of general agreement on the definition and description of systems analyst and programmer positions poses severe personnel management problems for the data-processing manager who is expected to recruit, select, train, evaluate, and compensate the employees who occupy these positions.

ıctors as the duties of the programmer, the degree of separation between the ystems-analysis and programming functions, the complexity of the data--rocessing systems, and the industry in which the business operates should robably be considered by the company in establishing educational standards. s the programmer's job is defined here, a college degree is not necessarily a ondition for employment in most organizations. What *is required,* however, is ıat the programmer have (1) analytical reasoning ability, (2) the ability to emember and concentrate on small details, (3) the drive and motivation to omplete programs without direct supervision, (4) the patience and persever-ıce to search for small errors in programs, (5) the accuracy to minimize the umber of such errors, and (6) the creativeness to develop new problem-solving echniques. Such people are in short supply relative to the rapidly growing need or their services.

OMPUTER OPERATIONS

he duties of the *computer operator* include setting up the processor and related quipment, starting the program run, checking to ensure proper operation, and nloading equipment at the end of a run. Some knowledge of programming is eeded. A high-school education is often acceptable, although additional ducational levels may be specified. *Keypunch operators,* a media *librarian* who aintains control over master tape and card files, and various other clerks and perators of peripheral equipment may be needed in the operations area. The taffing of operations positions generally presents no problem.

ECRUITING POTENTIAL CANDIDATES

prerequisite to sound staffing procedures is the preparation of job descriptions nd job specifications for the new positions to be filled. A *job description* efines the duties which must be performed and the equipment which is used, ndicates the degree of supervision which is given and received, and describes the orking conditions associated with the position. A *job specification* identifies ıe qualifications which candidates for each job should possess. Job specifi-ations include the levels of education, experience, and training considered ecessary to perform each job adequately. Also included is a statement outlining ıe physical and communication skills needed as well as the personality traits esired. In summary, job descriptions deal with the work itself, while job pecifications deal with the human qualifications needed by those who are to do ıe work. Brief descriptions and specifications were outlined above for the more nportant new jobs. These facts are useful (1) for staffing purposes, since both ıe recruiter and the candidate must know what is needed and expected; (2) for age purposes in determining the relative worth of the new jobs; (3) for job valuation purposes; and (4) for manpower planning purposes (it is desirable to ire new employees with potential to move into more responsible positions).

Two general procedures are often used to recruit candidates for new jobs. *One procedure* is to review personnel records and supervisory recommendations (or application forms and references in the case of nonemployee candidates) to compile a selective list of people qualified. People on this screened list are then contacted to see if they might be interested. The main weakness of this approach is that qualified candidates may be overlooked. *A second "reserve pool" procedure* is to announce the openings to all employees and invite them to make application if interested. Those applicants who appear to possess the necessary qualifications join the pool from which initial and subsequent openings are filled. Printed advertisements, outside employment agencies, contacts made at professional meetings, the knowledge of vendor representatives—all of these resources can be used to secure nonemployee applications.

The data-processing manager may sometimes be hired from an outside source to supervise an initial computer installation. The big disadvantage of this approach is that the person hired has little knowledge of the firm or of the personnel with whom he must work. Perhaps a preferable choice would be to appoint someone in the company who has the managerial qualifications and give him the required technical training. In staffing other vacancies, too, most firms prefer to select suitable candidates from within and to train them in the necessary skills. This approach is particularly valid in the case of systems analysts who must be familiar with company operations.

Programmers are more likely to be recruited from outside than analysts and other data-processing employees. This may be especially true when the programming job is considered to be basically coding and includes little in the way of systems work. In staffing programming jobs requiring some degree of systems analysis, a firm may give technical training to people possessing a knowledge of the business or it may hire experienced programmers (or programmer trainees) and school them in company policies, problems, and operations. Businesses have usually found that *when suitable candidates are available,* the first approach is preferable. Furthermore, with the shortage of skilled computer technicians becoming more intense, the recruitment of experienced personnel will become a more expensive and less dependable way of meeting future staffing requirements. In spite of these considerations, however, hiring experienced programmers may help speed up the conversion process. Many organizations have found that programmers skilled in the use of the hardware ordered for the new system are a valuable complement to company trainees.

SELECTION PROCEDURES

Once possible candidates have been identified, it is then necessary to balance and compare their qualifications with those listed in the job specifications. Sorting out the "best" applicants is a difficult job. The screening process generally involves the use of such selection devices as *aptitude tests, personal interviews,*

and careful *examination of records* indicating the candidate's educational background, experience, and work habits. A frequently used approach in the selection of analyst and programmer trainees is to give candidates an aptitude test and then to follow up with interviews and careful record examinations on all who receive satisfactory test scores.[4] In the selection of *experienced* programmers, personal interviews and personal or telephone contacts with parties familiar with the work of the candidate are of particular importance. Proficiency tests are sometimes used to check on the ability of a candidate to program a test problem.

A *programmer aptitude test* is a form of general intelligence test which *attempts* to measure the ability of a person to acquire whatever skills are needed to become a successful programmer. Although there is lack of agreement about the ability of these tests actually to measure what they claim to measure, when carefully used they may give an indication of a person's ability to reason in arithmetic and abstract terms. Since this ability is considered to be an important prerequisite for many data-processing jobs, the test may serve as a screening aid. But good test performance alone does not necessarily mean that the candidate will be a successful programmer. The tests do not measure motivation, and they may not begin to measure all the other qualities that may be required. In short, programmer aptitude tests may provide clues, but they should not be the only selection device employed. Tests are also used in the selection of computer-operations personnel. These tests measure manual dexterity, mechanical aptitude, clerical aptitude, etc., and they generally yield satisfactory results.

Selection decisions follow the testing, interviewing, and background-investigation phases. The chosen candidates must then be trained to prepare them for their new duties.

TRAINING SELECTED EMPLOYEES

Before looking at the approaches taken to train data-processing personnel, it is proper to mention here that *noncomputer personnel* should also receive exposure to data-processing concepts. It is especially desirable that top executives, operating managers, and other key employees be introduced to (1) the basic fundamentals of computers and data processing, (2) the uses and limitations of modern information systems, (3) the new concepts associated with the information-processing revolution, and (4) the implications of computer usage for managers and the managerial environment. Such an exposure will

[4] Is it logical, however, to attempt to measure a candidate's aptitude for a particular job in the absence of a job definition and description? Can a test measure a person's aptitude to perform in an undefined capacity?

enable noncomputer personnel to see how their operating needs can be served; it may serve to show them why knowledge of information processing is important; and it may help to reduce resistance to changes being made in processing procedures. Training seminars for noncomputer personnel are conducted by consulting organizations, professional associations, equipment vendors, colleges and universities, and company employees.

Extensive training must be given to those selected to be systems analysts and programmers.[5] In addition to having a *knowledge of the business and the industry,* the systems analyst must also understand the *techniques of systems analysis and design.* There is little uniformity at the present time in the methods used to train ("educate" is probably a better word) analysts to meet the latter requirement. A good grounding in the "core" courses found in collegiate schools of business combined with further emphasis on accounting systems, communication skills, mathematics, and statistics are felt by many to be prerequisites to more specialized systems training. There are several universities which offer degree programs in computer science; courses in systems analysis are sometimes included in their curricula. Vendors teach machine-dependent skills to their customer trainees, but since systems analysis is independent of machines, they do not offer much in the way of formal systems training. (Their site representatives, of course, frequently provide some on-the-job training in systems-analysis techniques.) Consulting firms and organizations such as the American Management Association conduct systems-analysis seminars on a limited basis. Correspondence courses in systems work are offered by the Association of Systems Management and others.

A third requirement of the analyst is that he possess a *general understanding of computer hardware and software.* Most of the formal training given to analysts during the computer preparation period is in this area; it is usual for this training to parallel or be identical with the formal training received by programmers.

The usual method employed to introduce analyst and programmer trainees to hardware and software concepts is first to enroll them in the vendor's programming courses. These courses introduce the trainees to the hardware which has been ordered and to programming languages which can be used. The emphasis is generally placed on coding. The courses vary in length from one to six weeks; they are usually offered at a vendor's training site. Following satisfactory completion of the vendor's course, the novice programmers—for at this stage they have only a rudimentary grasp of the subject of programming—receive additional on-the-job instruction from the vendor's site representative and from other experienced programmers who may be available.

[5] A detailed outline of the kind of training program needed to prepare workers for both of these positions is presented by Richard G. Canning in the reading at the end of this chapter entitled "Needed: A Planned Training Program."

Programmer training is a continuous, lengthy, and expensive process. To the surprise (and dismay) of many executives, it has been found that *at least* six months is generally required before programmers attain a *minimum* level of proficiency. Training costs per programmer may run into the thousands of dollars. In addition to the training available from vendors, programming skills are also taught by consultants, professional organizations, colleges and universities, and vocational schools. Companies with computer experience sometimes run their own formal training programs.

Equipment manufacturers and vocational schools offer brief courses to train operators of peripheral equipment. On-the-job training is often the only preparation required. Because of their need to know some programming, computer operators are often sent to the vendor's programming course.

Selecting and training employees for new positions are, of course, important aspects of staffing for computers. But executives cannot concentrate all their attention on these personnel aspects if they hope to achieve organizational goals. Proper consideration must also be given to the questions (1) of reducing employee resistance to change, and (2) of alleviating hardships that can be caused by job displacement. We shall consider these matters in the remainder of this chaper.

RESISTANCE TO CHANGE

It was observed early in Chapter 4 that "a system may fail to achieve company goals (even though it is technically and economically feasible) if company personnel are not sold on it and do not want to make it work." In too many cases, however, company personnel *have not been convinced* of the merits of the changes taking place and no attempt has been made to counter this attitude. Why not? One reason is that executives and data-processing specialists have too frequently become so preoccupied with problems of a technical nature that they have ignored the human factors involved in the transition.[6] In short, the emphasis has too often been placed on work rather than on workers.

Personnel preparations should receive considerable attention during the feasibility-study period and at the same time that technical preparations are being made, so that employees will accept changes with a minimum of resistance. That such resistance can endanger the entire project is vividly shown by the following statement made to the author by a data-processing manager whose company was *dropping the use of electronic data processing* (EDP):[7]

[6] For an excellent discussion of these human factors, see the reading at the end of this chapter by Bower and Sefert entitled "Human Factors in System Design."

[7] See Donald H. Sanders, *Introducing Computers to Small Business,* Data Processing Management Association, Park Ridge, Ill., 1966, p. 96. For details on the resistance to change experienced by small firms, see Chap. 5 of this book.

Office supervisory personnel failed to comply with the detailed new procedures due to disinterest, and this is why EDP has not worked. We couldn't get these lamebrains to do what they were told to do and we didn't have necessary direct communication with top management.

There were two basic reasons for the complete failure of this installation. One reason was lack of proper personnel preparation; the other reason was that when almost inevitable resistance to the change then occurred, the top management support vital to overcoming this opposition was also lacking. Such resistance to change is, of course, not new. The first punched card machine was built by a French weaver named Jacquard. The cards contained punched instructions which enabled the machine to weave designs into cloth. In the early 1800s in Lyons, France, the Frenchman was physically attacked and his equipment wrecked by workers who feared that the machine was a threat to their job security.

FORMS OF RESISTANCE

Resistance to change is the rule rather than the exception and it may appear in many forms. The extreme forms are explained by Heckmann and Huneryager in these words:[8]

At one extreme people suffer a temporary disequilibrium in need satisfaction, ask a few questions about the change, quickly adjust to it, and resume their previous behavior. At the other extreme, reaction can take the form of open opposition, rebellion, and even destruction.

Between these extremes may be found a number of other symptoms including the following:

1. *Withholding data and information.* It is not uncommon during the feasibility study for employees to withhold information about current operations. Even after the computer is installed, input data may be withheld or turned in late.
2. *Providing inaccurate information.* Input data containing known inaccuracies are submitted to sabotage processing results.
3. *Distrusting computer output.* Some employees continue to maintain old methods after the conversion is made. In one case it was found that "the payroll supervisor was insisting that his clerks recalculate the pay of the company's 1,000 hourly workers after each payroll had been completed by the IBM 1401."[9]

[8] I. L. Heckmann, Jr., and S. G. Huneryager, *Human Relations in Management*, South-Western Publishing Company, Cincinnati, Ohio, 1960, p. 425.
[9] George Berkwitt, "Middle Managers vs. the Computer," *Dun's Review*, vol. 88, p. 42, November 1966. This article is reprinted at the end of Chap. 5.

4 *Showing lowered morale.* A general lowering of employee morale may result in lack of cooperation, sullen hostility, sloppy effort, an attitude of indifference, jealousy among workers, etc.

Although employee reaction to change depends, of course, on the individual, it also depends on answers to such questions as: (1) What are the nature and magnitude of the changes? (2) Why are they being made? (3) Who is backing them? (4) Who will administer them? (5) When will they take place? (6) In what departments will they be felt? (7) What has been the extent of personnel preparation? (8) Does the firm have a history of good personnel relations? (9) Does the firm have a reputation for innovation and change?

REASONS FOR RESISTANCE

It is not too difficult to compile a list of motivating forces which may stimulate one or more individuals to seek business changes. Included in such a list are (1) dissatisfaction with the *status quo* together with a desire for greater knowledge and understanding; (2) the desire to create, to excel, to be a leader in the use of new techniques and in the development of new products and services; and (3) the pursuit of economic benefits.

But the changes sought by some may appear to others to be a *threat*—a threat which prevents them from satisfying certain basic needs or one which decreases the level of their need satisfaction. That a proposed change *does not* actually affect an employee's need satisfaction may be irrelevant from a resistance standpoint. *What is relevant* in this situation is that if the employee *believes* that he is threatened by the proposed change, he will no longer feel secure. "Only when he recognizes that the change will not affect his need satisfaction, or when he adapts himself to a change that in fact does decrease or prevent the satisfaction of a need, will equilibrium return and resistance disappear."[10]

What are these needs which motivate behavior? What needs do people seek to satisfy? Psychologists tell us that human needs may be classified into a series of ranks or levels as follows:[11]

1 *Physiological needs.* Included in this lowest-level category are the needs for food, clothing, shelter, and sleep. They are necessary for survival and thus receive first priority. When thwarted, these needs override in importance all others in motivating behavior; when regularly satisfied, they cease to direct human behavior.

2 *Safety needs.* The needs for protection against danger, threat, or deprivation begin to dominate man's behavior when the physiological needs are satisfied.

[10] Heckmann and Huneryager, *op. cit.*, p. 421.

[11] See Douglas McGregor, *The Human Side of Enterprise*, McGraw-Hill Book Company, New York, 1960, pp. 36-39.

cial needs. When the above needs are satisfied, social needs—i.e., the need belong to a group, to associate, and to be accepted by others—become portant motivators.

o needs. When the first three need levels are reasonably satisfied. ego eds become important in behavior motivation. There are two kinds of oistic needs: (1) those that relate to the *self-esteem* of an individual, e.g., e needs for self-confidence, for achievement, and for independence, and (2) ose that relate to the *reputation* of an individual, e.g., the needs for status, r recognition, and for respect. "Unlike the lower needs, these are rarely tistied; man seeks indefinitely for more satisfaction of these needs once ey have become important to him."[12]

lf-fulfillment needs. The final level in the need hierarchy reflects the sire of an individual to realize his own potential, to continue to develop, d to be creative.[13]

inst the above background of needs which man seeks to satisfy, we may dentify some of the *reasons why people are motivated to resist the change ctronic data processing:*

e threat to safety-need satisfaction. Computers have a reputation for placing people; therefore, there is the understandable fear of loss of nployment and/or of reduction in salary.

e reduction in social-need satisfaction. The introduction of a computer ten calls for a reorganization of departments and work groups. When ange causes a breaking up of compatible human relationships and a aligning of personnel, it also causes a reduction in social-need satisfaction. esistance to such a proposed change may be anticipated; it diminishes to the tent that the displaced individual forms new friendships in, associates with, d is accepted by the new group.

e reduction in ego-need satisfaction. The individual needs to feel f-confident; but self-confidence may be shaken by the lack of knowledge out, and experience with, computers. The equipment is strange to him, and may fear that he will be unable to acquire the new skills necessary to work th it. In short, the individual's self-esteem may suffer as a result of the ange; therefore, the change may be resisted. Egoistic needs relating to the putation of the individual are also threatened by change. Fear of loss of atus and/or prestige is an important reason for resistance by both anagers and employees. For example, if the change threatens to reduce the mber of employees in, and the importance of, a department, then the

l., p. 38.

may now rephrase an earlier statement in this way: The attempt to satisfy ego and -fulfillment needs by one individual through the sponsorship of innovation and change appear to others to threaten the satisfaction of *their* safety, social, and ego needs.

department manager may oppose the change because to admit that the change is needed is to admit that he has tolerated inefficiency—an admission which can hardly be expected to enhance his reputation. An employee who has the respect of fellow workers because of his knowledge of the old system may also suffer a loss of prestige. When new procedures are installed, he is no longer looked to for information because his knowledge of the new procedures may not be any greater than that of other workers.

EMPLOYEES WHO RESIST

It is generally conceded that nonsupervisory employees may resist change because they fear they will (1) lose their jobs or be downgraded, (2) be transferred away from their friends, (3) be unable to acquire the needed new skills, and/or (4) lose status and prestige. A greater obstacle to successful computer operations, however, may be *managerial* resistance to change. Although a manager may suffer economic loss because of the change to computer processing,[14] the more usual motivating force behind his resistance, as we have just seen, is the threat of a reduction in ego-need satisfaction. Many managers feel that their positions are being threatened (and indeed this is sometimes the case). In a very real sense, those who may be most affected by the change are being asked to help plan and implement it. But it is unrealistic to expect a manager to be enthusiastic about changes which threaten his position. Proper personnel preparation must include managers as well as nonsupervisory employees.

SUGGESTIONS FOR REDUCING RESISTANCE

Unfortunately, there is no simple formula which prevents resistance and ensures a successful computer transition. But there are some guidelines and suggestions which have been developed as a result of practical experience and social research which may, when used with care, help to reduce the level of employee opposition. Included in these suggestions are steps to:

1 *Keep employees informed.* Information relating to the effects of the change on their jobs should be periodically presented to personnel at all levels. Topics discussed should include loss of jobs, transfers, the extent of necessary retraining, the reasons for (and the benefits of) the change, the effect on various departments, and what is being done to alleviate employee hardships. Basic company objectives should be reviewed; the motives behind these objectives should be identified; and the contribution which the change makes to goal

[14] And the pessimistic predictions being made by some writers about the number of future middle management positions does little to relieve the apprehension some managers may have about the possibility of economic loss.

achievement should be explained. When possible, employees should be assured that the change will not interfere with the satisfaction of their personal needs.

2 *Seek employee participation.* Employees are more likely to support and accept changes which they have a hand in creating. In addition to yielding valuable information during the feasibility study, design sessions also help reduce later resistance by allowing managers to have a say in the planning of the project. Psychologists tell us that participation has three beneficial effects. First, it helps the employee satisfy ego and self-fulfillment needs. Second, it gives the employee some degree of control over the change and thus contributes to a greater feeling of security. And third, the fear of the unknown is removed. The *participation of supervisors and informal group leaders* may greatly reduce the level of resistance. But participation is not a gimmick to manipulate people. Employees asked to participate must be respected and treated with dignity, and their suggestions must be carefully considered.

3 *Use managerial evaluation.* Make their ability to handle change one of the criteria for evaluating supervisors' managerial capability. Let them know that this criterion has been established.

4 *Consider the timing of the change.* Do not set unreasonable conversion deadlines. Give personnel time to get used to one major change before another is initiated.

PLANNING FOR DISPLACEMENT

Do computers cause widespread unemployment among white-collar workers? Printed sources could be cited to support this position. But other printed sources could also be quoted which take the position that the computer (and technological change in general) provides increased job opportunities. To some extent the controversy is fed by a failure on the part of some writers to make a distinction between unemployment and displacement. Those who are optimistic about the effects of computers on employment are generally looking at the effect of technological change on the *total employment* picture—i.e., they are looking at the effect on the *total number of jobs* in the labor market. Those who view the picture pessimistically are frequently looking at the short-run effects of *displacement* on *specific occupational categories*—i.e., they are looking at the reduction in the number of jobs in a specific segment of the labor force.

Unemployment and displacement are not the same. Unemployment refers to the total number of people involuntarily out of work. *Displacement* occurs when the jobs of individual workers are eliminated as a result of technological change. *If* these displaced workers cannot find similar jobs elsewhere and *if* they cannot find work in other occupations, then there is, indeed, an increase in the unemployment figures. But has the development of the computer caused a larger number of people to be unemployed than would otherwise have been the case?

In other words, have computers reduced the total number of jobs available in the total labor market? Professor Yale Brozen, University of Chicago economist, expresses the views of most authorities when he writes:[15]

> *The reigning economic myth is that automation causes unemployment. It has only a slight element of truth—just enough to make the proposition plausible. Automation does cause displacement. A few become unemployed because of it. However, it does not create unemployment in the sense that a larger number are unemployed than would have been if no automation had occurred. . . .Many persons point to specific persons unemployed as a result of [automation]. What they fail to do is point to the unemployed who found jobs because of automation or to those who would have joined the jobless if new technology had not appeared.*

It is beyond the scope of this book to go into the economic causes of unemployment. We may conclude this topic by mentioning that most economists are of the belief (1) that displacement must not be prevented, and (2) that unemployment is best avoided by high levels of capital investment, unhampered mobility of capital and labor, and a continuing high level of technological progress. The alternative to technological progress is economic stagnation.

Although technological change is beneficial to the nation as a whole and in the long run, this does not mean that the short-run effects of displacement on particular individuals are not a matter of importance. A displaced person may understand the long-run benefits; but he is likely to be in greater sympathy with the famous economist who noted wryly that "in the long run we are all dead." It is true that displacement must not be prevented; but leaders in business, government, and labor must make every effort to see that displacement does not lead to unemployment.

BUSINESS DISPLACEMENT EXPERIENCE

Studies have shown that the computer can displace large numbers of people. For example, in a study of 32 companies, Ernest Dale found some substantial changes. He reported reductions of 4,000 people in an insurance company and 1,000 people in an oil company. All except three of the 32 firms ". . .used fewer people for the same amount of work or found that the same number of people could do more work than before."[16] Although other examples could be given, this one serves to show that many jobs can be eliminated. This fact, of course, is

[15] Yale Brozen, "Putting Economics and Automation in Perspective," *Automation,* vol. 11, p. 30, April, 1964.

[16] Ernest Dale, *Management: Theory and Practice,* McGraw-Hill Book Company, New York, 1965, p. 678.

not surprising; as you will remember, a reduction in clerical labor costs is often an objective sought by businesses.

But a number of other examples could be cited which would show little or no displacement. The extent to which displacement actually occurs, and the significance of the problem in particular cases, depends in large measure on the following factors:

1 *The rate of growth of the firm and the economy.* If the company is growing rapidly so that more work must be done to handle the expanding business, then there may be little or no effect on the number of clerical workers employed. The computer enables workers to be more productive; but increases in the demand for a company's output can prevent a layoff problem. Reassignment of surplus workers to different departments may, of course, be required. If a worker must be laid off, he will have greater opportunity to find employment elsewhere if the economy is in a period of prosperity. It is fortunate that most computer installations have occurred during relatively prosperous periods.

2 *The objectives sought.* Is the company acquiring a computer for processing purposes which could not otherwise be considered? Is the goal to do more work with present employees? Or is it to save money by eliminating existing jobs? Objectives obviously play a part in determining the degree of displacement.

3 *The care in planning and preparation.* Business executives should give careful thought to the displacement problems which they are likely to encounter. It should be remembered that fear of displacement is a cause of resistance to change. If displacement is not expected, employees should be so informed; if jobs are to be eliminated, plans should be made to protect present employees as much as possible. Employees in departments where reductions are expected can be given the first chance to fill vacancies occurring elsewhere in the company. Vacancies in affected departments can be left unfilled, they can be filled by new employees who have the ability to adjust quickly to different positions, or they can be filled with temporary outside help. Special programs can be established to train soon-to-be-surplus workers in skills needed in other areas.

4 *The type of occupations threatened.* Up to the present time, most of the jobs which have been eliminated have been of a clerical nature and have usually been held by young women who can be transferred to other departments without too much difficulty. In the past, few clerical workers were laid off in larger businesses when job reductions occurred.[17] This was possible because those workers in affected departments who quit during the many months between the time the computer order was placed and the time the conversion was completed were simply not replaced. Thus, a potentially serious layoff

[17]Small firms have not been as successful in preventing layoffs, possibly because there may not have been other departments to which surplus workers could be reassigned.

problem often has not developed. (However, employables who have a minimum amount of training and who seek *to enter* the clerical labor force may face shrinking opportunities because of the leveling off in the rate of growth of certain clerical job categories in the past several years.) When the affected jobs are *not* of the clerical type, the displacement problem is likely to be much more severe. Attrition and turnover may not, in these situations, be of much help. The affected workers may be older employees or lower-level managers whose skills are no longer needed. They are not likely to quit, but they may find it difficult to retrain for jobs at an appropriate level. Such personnel problems can be perplexing; and in the future, as computer applications become more sophisticated and move into more operating areas, they can be expected to occur with increasing frequency.

DISCUSSION QUESTIONS

1 Explain the job functions of the following data-processing personnel:
   (a) data-processing managers,
   (b) systems analysts,
   (c) programmers, and
   (d) computer operators.

2 What qualifications should candidates for the above jobs possess?

3 What is
   (a) a job description?
   (b) a job specification?
   (c) Why are job descriptions and specifications needed?

4 Discuss the possible procedures which may be used to recruit candidates for new jobs.

5 What selection procedures may be used to fill data-processing positions?

6 (a) Why should noncomputer personnel receive data-processing training?
   (b) What kind of training should they receive?

7 In what forms may personnel resistance to change appear?

8 What are the needs which motivate human behavior?

9 (a) Why do managers resist change?
   (b) Why do employees resist?

10 How may resistance to change be reduced?

11 What is the distinction between displacement and unemployment?

12 What factors influence the significance of the displacement problem when computers are introduced into businesses?

CHAPTER SIX READINGS

INTRODUCTION TO READINGS 24 THROUGH 26

24 After pointing out that the data-processing industry has not had much time for, or inclination toward, personnel management, Dick H. Brandon writes that this situation must be corrected if realistic and effective computer use is to be achieved. The elements of personnel management applicable to data processing are identified and discussed, and the poor performance of data-processing management in applying these elements is noted. Suggestions for improvement are outlined.

25 In this reading Richard G. Canning presents the elements of what is needed in the way of a comprehensive training program for systems analysts and programmers. The training program content is divided into background, thorough grounding, and specific training sections. Some possible objections to and the advantages of the type of program outlined here are examined.

26 This article by Professors Bower and Sefert emphasizes the human-factors principle of system design—i.e., it points out that the design of a system should be consistent with applicable human factors since people are responsible for the effectiveness of the system. Some of the important human factors that should be considered during the change process are presented. The effects of change on top and middle managers and nonsupervisory employees are examined; causes of resistance to change are uncovered; and techniques for achieving successful change are discussed.

READING 24 PERSONNEL MANAGEMENT—MISSING LINK IN DATA PROCESSING*

DICK H. BRANDON

The data processing industry, for all its dynamism, has come under increasing criticism. Within the industry problems of management communication, user communication, staff shortages, management control difficulty, and a host of others are discussed at conferences and seminars, and are endlessly described in print.

*Reprinted from *Journal of Data Management,* vol. 6, pp. 50-52ff., June, 1968. Reprinted by permission from the Data Processing Management Association, Park Ridge, Ill. Mr. Brandon is president of Brandon Applied Systems, Inc.

If these problems are analyzed carefully, it will be readily recognized that they are all *people* problems. In general, computers perform well, and their technical capability has long since outstripped man's ability to use them effectively. Thus, the problems can be traced to people, whether it be inadequate numbers, poor quality, or poorly trained personnel. Solving the problems, therefore, requires consideration of all the aspects of people in a working environment, in two words: *personnel management.*

The data processing industry has not had much time for, or inclination toward, personnel management. The rapid growth of the industry and the many problems associated with this growth have left the typical data processing manager without much spare time in which to expand his skills as a people manager, or even to study the basic techniques of personnel management. The data processing manager usually has evolved from accounting or engineering functions, two disciplines which are not particularly noted as avid developers of personnel managers.

The concepts of personnel management are often considered inapplicable to data processing. Personnel management typically started in manufacturing shops or in large organizations with massive clerical staffs. Applying personnel management techniques to the "professions" in business came much later and only to the more sophisticated organizations. As a result, data processing personnel in most installations have not been subject to much effective personnel management. This has hindered progress in solving the people problems of data processing, and must be corrected rapidly if realistic and effective computer use is to be achieved.

ELEMENTS OF PERSONNEL MANAGEMENT

Personnel management generally is the discipline of guiding an employee in his career, from recruitment to retirement. Although personnel specialists may not agree with the classification, for purposes of illustrating its application to data processing, 10 functions will be defined.

1 Functional job definition. Before the personnel specialist can classify or evaluate a position, the functions to be performed must be defined. This requires a brief task description, essentially defining the scope and boundaries of the job. Often this basic definition is determined by a trade organization, a trade union, industry practice, or external requirements.

An airline pilot's functions are defined partially by industry practice, partially by the nature of his tools, and partially by the Federal Aviation Agency. An accountant operates under control of laws, the S.E.C., and under rules promulgated by the American Institute of CPA's. Draftsmen have the American Standards for blueprints, building codes, engineering practices and the like. But what of systems analysts?

2 Job Description. The formal outgrowth of job definition is the job description used by personnel management to establish formal constraints and responsibilities for each job. The job description typically includes

reporting relationship of the position,
administrative responsibility,
technical or functional responsibility,
contacts made in the job,
supervision exercised in the job,
amount of supervision required,
educational qualifications,
experience qualifications, and
specialized training required.

In addition, salary data may be included and performance standards established where applicable. The job description is general. It does not describe the characteristics or performance of an *incumbent;* rather it defines the job totally independently of whether or not it is being performed properly.

3 Recruitment. With an accurate job description, it is possible to define requirements to the labor market and to recruit potential candidates for screening, selection and hiring. The process of recruitment starts with an identification of sources and media. The first choice is between recruitment inside or outside the company. Inside recruitment has advantages of obtaining already loyal, informed personnel, with the added benefit of internal promotion opportunity. It has the disadvantage of requiring a chain of replacements, and of limiting the possible scope of entrants. Thus, both are considered. Thereafter, external media decisions are made. Sources typically include friends of employees, employment agencies, newspaper advertising, or school graduates.

4 Screening, selection and hiring. When candidates have been obtained, the difficult function of selection must be performed. Step 1 is generally a screening, from a resume or job application, to insure that the basic prerequisites match the job description. This is followed by more comprehensive selection methods using tests, interviews, or actual practice. There is a broad range of selection methods, from proficiency tests to intelligence tests, to stress interviews, to the hiring hall. The actual hiring of selected candidates may involve administrative procedures, medical examinations, loyalty oaths, security checks and so on.

5 Basic training. The successful candidate generally must be exposed to the organization and possibly to new job skills or new job practices. An orientation program is often followed by both formal (classroom) and on-the-job training, often following rigid and well defined procedures and steps in the training process. The variety and types of training are infinite. Doctors require years of internship and residency; airline pilots require months of formal training, followed by a rigorous apprenticeship program. Typists, whose basic skill may be a prerequisite, often require no more than the simplest orientation to the organization.

6 Job evaluation. A continuing formal function of personnel management, job evaluation is an assessment of the job in terms of physical, mental and other requirements. The job is rated based on various scales relative to other jobs and, in some cases, to some absolute standard. Factors such as weights of lift, boredom, routine or repetitive functions, mental concentration and working environment, are all assessed to give a general picture of the relative difficulty of the job. The output of job evaluation can be used in salary administration, in establishing personal, fatigue or delay allowances, in performance measurement, or simply in improving the job or making it more tolerable to the employee.

7 Salary administration. A major function of personnel management is salary and wage administration. This is based initially on the job description and the job evaluation. Thereafter it is a function of negotiation with unions, or keeping track of factors such as the labor market and the cost of living. Formal salary administration programs establish wage grades for each job category. Associated with each grade is a salary range—from the entrant level to the maximum possible—determined by tenure, merit increases, or individual proficiency evaluations. Wage administration generally relates to hourly workers, and may be concerned with incentives, bonuses, piecework and other production-related compensation plans.

8 Promotion and transfer. The upgrading and reassignment of individuals to jobs is important in overall career planning and in organizational manpower forecasting. Thus, personnel management concerns itself with the normal promotion ladder from one job to the next as, for example, from computer operator to programmer, or from bus driver to starter.

In many industries the promotion ladder is very formalized, and personnel administration is vital to its continuance. The armed forces, for example, maintain rigid promotion standards; failure of an officer to achieve a certain level at a given age often requires his resignation from the service. The lateral transfer of employees is also an important function. A multiple number of assignments broadens the individual and provides greater corporate flexibility. However, the recordkeeping and job description functions are vital to effective programs in these areas.

9 Continuing job development. Training is required not only when a new employee joins the organization, but also when he is transferred or promoted. Many jobs also require continuing training to keep personnel up-to-date with new techniques as, for example, computer systems analysts. Thus, the personnel management function has a continuing responsibility for training, upgrading of skills, and professional development.

10 Personnel records administration. The final function of personnel management is the administrative retention of detailed personnel records. Generally these records fall into the following categories:

Employment history records showing assignments and positions held, with comments from supervisory staff.

Attendance records showing punctuality and absenses.
Benefits records identifying the benefits received.
Skills records listing the employee's skills, educational achievements, capabilities, hobbies and primary characteristics.

These records need not be separate, of course, and often are included in a computer-based personnel management system, or in a total employee data base.

THE PERFORMANCE OF DATA PROCESSING MANAGEMENT

An examination of these 10 functions as they relate to data processing suggests that the average data processing manager is unaware of the details of personnel management, and that the *industry* as a whole has done little to educate him, or to provide him with the necessary tools. Consider in review the same 10 functions as applied to data processing:

1 Job definition. The lack of standards in data processing is well known and well documented. There are no effective functional definitions of any of the jobs performed in the data processing environment. In fact, considerable controversy exists about even such basic factors as the difference between analysts and programmers. The tasks of analysis, programming and even operations and control are not defined, and uniform standards are effectively nonexistent.

2 Job descriptions. A similar lack appears to apply to complete job descriptions. The only current publication which features detailed description of jobs in the data processing environment is one published by a prominent equipment manufacturer.[1] There are no industry-wide job descriptions, and no current efforts are being made in this direction.

3 Recruitment. Recruitment of data processing personnel in the current U.S. labor market is mainly catch-as-catch can. The shortages of competent staff create significant difficulties in organizing an effective recruitment program. Many unethical employment agencies have jumped into the gap as "body brokers," although there are several excellent agencies.

4 Selection. The selection practices used by data processing management are, to say the least, inexact. Computer operators are selected by some generally vague criteria. Luckily it does not appear to be overly significant; general intelligence and basic dexterity appear to satisfy the need.

Programmers are a different story. They are most often selected on the basis of a programming aptitude test, whose validity is subject to question and which further appears to segregate a number of undesirable characteristics as well.

The process is worse for systems analysts and managers, who appear to be selected by some form of divining rod. No practical selection mechanism is currently available for either of these two categories.

[1] IBM—Organizing the Data Processing Installation—1965 Form No. C 20-1622-0

5 Basic training. Data processing managers simply over-rely on equipment manufacturers. Since vendors have "traditionally" supplied *basic* training for operators and programmers, it is blithely assumed to be satisfactory. In fact, however, operators need some exposure to application procedures, and programmers should have a healthy dose of training in programming methods and techniques. Again, the analyst and manager are left out; the vendor does not consider their skills "machine-dependent," and no really effective training programs are provided.

6 Job evaluation. There is no current record of any data processing installation today practicing effective job evaluation techniques.

7 Salary administration. In the absence of job evaluation and job descriptions, it is difficult to see how effective salary administration can take place. Salaries are largely established by the market place, and are governed by the laws of supply and demand. Salary adjustments are made to correspond to a market spiral caused by staff shortages. There is no effective measurement of performance, and there are no realistic criteria for salary adjustment, even if it were possible to ignore external conditions.

8 Promotion and transfer. To the uninitiated it appears as if there is a typical promotion chain operating within the data processing structure. After all, there are five job families with ascending skill requirements, and nothing appears more reasonable than to promote

clerical staff to operations
operators to programmers
programmers to systems analysts
analysts to managers, and
managers to ?

This logic does not survive the recognition that the *prerequisites* for each job are different, thereby invalidating the ability of an individual to progress through the chain. It appears equally difficult to promote to elements of the organization outside data processing. The programmer or analyst is already paid at a premium rate, and is often uninterested in obsoleting his prime skills through a potentially temporary stay outside of data processing. A shortage of staff, coupled with lack of effective documentation, further decreases the likelihood of any kind of transfer.

9 Professional development. This area is relatively well covered. Conferences, papers, articles and the ready availability of short training courses have made this a reasonably successful activity. It has had one disadvantage: the polarization of interest around a "data processing community", necessarily away from the industry in which the employer operates. As a result, data processing people tend to be more loyal to data processing than they are to their employers.

10 Personnel records. The area of personnel records is also well covered, this time by the effective work of the organization's personnel department. The basic

records are usually kept, although specialized data processing records are usually not available. It would be desirable, for example, to isolate machine and applications experience for each individual, and to identify specific language skills.

THE NEED It is easy to criticize the industry, and to observe that data processing management has not really recognized personnel management as a necessary and valuable asset to offset the many personnel problems. Some suggestions toward a solution are in order, in roughly the sequence of the personnel management functions:

1 Define, in simple terms, the tasks and functions performed by all personnel in data processing. For analysts and programmers, specify the output to be produced at each point, its contents, and the control or review points of the process.
2 Develop a set of basic job descriptions for the 15 to 20 key positions in data processing, from keypunch operator to data processing manager.
3 Establish, for each position so defined, the *prerequisite* characteristics of the ideal individual. Thus, for a systems analyst the prerequisites might read:

Education	Bachelor's degree or equivalent, preferably in applied science, economics, statistics, accounting or business administration.
Characteristics	Imagination/creativity, communicative skills, tact/diplomacy, organizational ability, initiative, I.Q. 115 to 120.
Previous experience required:	6 months to 1 year with the organization in any position and basic knowledge of business skills, such as accounting, economics, statistics.

4 Define the sources to be used for recruitment, in sequence of priority.
5 Establish, based on the prerequisite characteristics above, the necessary selection criteria, and the method to be used for identifying these. This will not be easy, especially for the position of systems analyst. For example, communicative skills should be quantified in some way, perhaps in terms of appearance, speaking ability, poise, and technical writing competence. Evaluation methods for these criteria will not be easy to define, and may include interviews, testing (as with I.Q.), and examination of employment records or school transcripts.
6 Define the training for each position, in terms of elements or modules necessary to take an individual, with the prerequisite characteristics, to the level of competence required to meet the tasks and responsibilities defined in the job description. Thus, modules for systems analysis training would include

    basic machine concepts,
    programming concepts,

basic systems analysis techniques,
on-the-job training—basic techniques,
advanced systems analysis techniques, and
on-the-job training—advanced techniques.

7 For each module defined, establish the techniques to be taught, and the method and depth to which they are to be taught. This will allow a determination of the time required to effectively teach the subject matter defined.
8 Based on the job descriptions and the training scope, the task of job evaluation can be set up. However, this is the responsibility of the personnel manager, and should be normally done by, or with the cooperation of his staff.
9 Set up a rudimentary salary administration program, again with the personnel manager. Establish ranges for each job, entrance levels, typical in-grade changes, promotion levels within and outside the position, and salary advancement based on increased skill and tenure in grade.
10 Establish a promotion policy which allows individuals to move within the position, as from programmer to senior programmer, and outside the position, *provided* that the prerequisites for the new position have been met by the candidate for promotion.
11 Formalize the professional development program and for each position define the approximate amount of time allowed for this function.

Define the characteristics and objectives of each element of the program, and prepare an annual schedule of activities.

These steps are generally not too difficult to be carried out by each data processing manager in cooperation with his personnel organization. It is clear that dependence on the data processing industry, or on its major suppliers, has not paid off to date. It is necessary therefore to act now, and on an individual basis to wipe out this missing link in the overall technology of data processing.

READING 24 DISCUSSION QUESTIONS

1 Why have personnel management concepts not been applied to the data-processing function?
2 (a) What are the elements of personnel management?
(b) Discuss these elements as applied to data processing.
3 Discuss the suggestions outlined for improving the management of data-processing personnel.

READING 25 NEEDED: A PLANNED TRAINING PROGRAM*

RICHARD G. CANNING

Based on our discussion with numerous people concerned with data processing training, we will present the elements of what is needed in the way of a comprehensive training program for system analysts and programmers. This suggested program can be used as a benchmark, against which other training programs might be measured.

Note that what is presented here is not an undergraduate college curriculum. The broader educational requirements are not considered. Rather, the program is aimed at the introductory training and upgrading training for system analysts and programmers.

THE TRAINING PROGRAM CONTENT

The subject matter for the training of system analysts and programmers divides itself into three general sections: background section, thorough grounding section, and specific training section.

BACKGROUND SECTION

THE BUSINESS ENVIRONMENT The following general subject areas should give the system analyst a better idea of the objectives of the enterprise:

Mechanics of the market place; business fluctuations and forecasting; economics and public policy.

The life cycle of products and services.

The role of the firm; business policy; company goals; organization and management theory.

Functional management of the firm; financial, marketing, production, personnel, legal; accounting principles.

Planning and control; budgeting; resource allocation; the planning-programming-budgeting system; internal controls; auditing principles.

For the specific firm: history; specific objectives; specific competition; position in the market place; organization; role of data processing department.

While most of this material is taught at many colleges and universities, the material to be presented in the training program should be carefully selected.

*Reprinted from *EDP Analyzer,* vol. 5, pp. 4-6 and 10-11, August, 1967. Reprinted by permission from Canning Publications, Inc., Vista, Calif. Mr. Canning is a consultant, an author of several books in data processing, and the publisher of *EDP Analyzer.*

The attempt here is not to try to duplicate the courses required for a Masters Degree in Business Administration. Rather, the intent is to select the material that is pertinent for the system analysts' role. The system analyst should try to see the organization from the perspective of overall company goals. He should obtain a macro view of the enterprise, and its position in the market.

People with a Business Administration education, and particularly a Masters in Business Administration, would already have much if not all of this education. For those who do not have such an educational background, the training should not go into great detail, such as a full course on conventional accounting principles. Rather, such material should be presented in overview form.

(The degree of detail to be presented is a controversial subject, of course. We are presenting our view, which has been arrived at following discussions with a number of people on this subject.)

QUANTITATIVE METHODS Since quantitative methods are expected to play an increasingly important role in both system design and management decisions, the following material should be presented:

Familiarization with the mathematics pertinent to management problems, including training in solving rudimentary problems; subjects should include algebra, matrix algebra, probability theory, statistics, design of experiments, and math of finance and accounting, including discounting and compounding.

Overview of the major types of quantitative models, including inventory, forecasting, scheduling, resource allocation, queuing, and replacement; analytic and simulation models.

As in the case of business environment, this training in quantitative methods is not aimed at making operations research practitioners of the system analysts. In the majority of cases, these men will not have the mathematical background to become such practitioners. The training is intended to give them some familiarization with the subject to aid communication with O.R. practitioners and to know when they must get help from such practitioners.

It is possible that some system analysts and programmers will find this training much to their liking, and will continue with their math so as to become operations research specialists. Others may find that they have been out of school so long that even elementary algebra is too much of a challenge, and thus will drop out of this training.

In general, an organization probably will want to tailor this background material to its specific interests. A governmental agency would be less interested in the marketplace mechanisms and more interested in public administration. A regulated utility also would have interests different from a non-regulated enterprise. Selection might be made among the different quantitative models, to pick the ones most appropriate to the enterprise.

THOROUGH GROUNDING SECTION

This section of the training program is aimed at the heart of the system analyst's job. It provides for the training of novice system analysts, the upgrading of experienced system analysts whose formal training has been limited, and the upgrading of programmers into system analysts.

THE SYSTEMS APPROACH TO BUSINESS FUNCTIONS Courses in this subject area would cover the following material:

- Integrated information systems; the inter-relationships between business functions; problems of creating an integrated information system.
- The impact of the new computer technology on management systems; reduction of lead times; faster response to changes in the business environment.
- Management information systems; management uses of computers; new approaches to management reporting.
- The role of application packages; training in industry-oriented applications packages; the integration of applications.
- The importance of searching for alternative system designs; cost-effectiveness evaluations; system simulation; use of quantitative models.
- Searching for significant improvements in performance in business functions, while considering the effect that such improvements might have on other functional areas within the business.

The industry-oriented courses presented by the computer manufacturers may fit well within this section of the training. However, from the above list, it should be apparent that the training should be broader than a computer manufacturer normally would provide.

The training should stress the inter-relationship of the functions of the business. One example might be the benefits and problems that will be encountered when consolidating production control records and financial records. Another example might be the consolidation of the plant loading operation and the budgeting operation. The training should deal with real-life problems—with the advantages that management sees in integration, and the practical problems of achieving it.

It should be mentioned that managers often forget about this area of inter-relationships of business functions—or, more precisely, do not give it the attention it deserves. We have participated in numerous system design sessions, involving six to eight key managers for periods from several days to two weeks. The goal of these sessions was to outline the preliminary design of a more integrated information processing system. Invariably, an important by-product of these sessions has been the education of the managers in the inter-relationships of the business. These men might have had ten years or more experience in their companies, and might hold positions such as manager of

roduction control, manager of purchasing, chief accountant, etc.—but they still ound they had much to learn about the other functions of their business.

NFORMATION SYSTEM DESIGN This subject area deals with the practices sed by system analysts in determining requirements for a new information ystem, and laying out the design of that system:

Introduction to information system concepts; elements of an information system; computer concepts; summary of available equipment; basic programming; proposal writing.
Introduction to data processing technology; batch systems; fast response systems; data communications; displays; file design; data controls; audit trail.
The analytical phase; determining user requirements; determining cost-performance trade-offs; setting system objectives.
The design phase; design strategy; searching for alternative solutions; use of simulation; cost-effectiveness concepts; preliminary design and evaluation; detailed design and evaluation; human factors considerations; systems and procedures consideration; project planning and control; documentation.
The implementation phase; strategies for implementation; the sociology of change; problems of introducing change and working with people.

This subject area is concerned with the principles of system analysis and lesign. But note that it goes quite a bit further than most of such courses that ve have encountered to date. It exposes the student to the different types of ystem designs (batch, fast response). It deals with cost-performance trade-offs ı the design process, and cost-effectiveness analysis of the alternative solutions. imulation should certainly be one of the tools used during system design, and erhaps simulation should be taught, at this point. We have chosen to include he training in simulation in the next section.

Note too that the training should cover human factors considerations, as well s the sociology (and psychology) of introducing changes into an ongoing peration. If operating people are suspicious of the systems people, resistance to hange will occur.

PECIFIC TRAINING SECTION

The objective in this part of the training program is to upgrade personnel in the ew technology. It is assumed that the introductory training has already been ccomplished—that is, that the students already know the principles of data rocessing. Training in this section would generally consist of short, intensive ourses aimed at specific subject matter. The course length would depend on vhether the students were simply to be made aware of new developments in the echnology, or whether they were being trained to put the subject matter to use ı their daily work (such as learning a new programming language).

DATA PROCESSING TECHNOLOGY This subject area deals more with the interests of the system analyst, but also might be used for upgrading programmers.

- Analysis and design for batch-sequential systems; fast response-random systems; interactive time-shared systems.
- Data communications system analysis and design.
- Direct access storage concepts.
- File organization, including inter-related and hierarchical files.
- Data retrieval; information retrieval; content retrieval from structured files.
- Decision tables as an analysis and design tool.
- Simulation as a design tool.

The computer manufacturers offer some courses that would fit within this subject area. Independent software firms are in a position to offer these courses; while some are taking this action, we would expect to see much more activity by these firms in the next few years.

It should be reiterated that the training courses in these subjects can range from short "awareness" courses to very detailed courses aimed at making the students proficient in using a technique.

PROGRAMMING TECHNOLOGY As the name implies, this subject area is directed mostly at the interests of programmers. However, short "awareness" courses might profitably be taken by system analysts, managers of data processing, and perhaps others.

- Business programming languages: procedural languages, such as COBOL, DETAB, PL/1, Fortran (for business purposes), Simscript, etc.; generalized file processing languages, such as Integrated Data Store, BEST, G.I.S., IMRADS, etc.
- Operating system fundamentals; tape oriented systems and disk oriented systems; system generation; data communications control program; inquiry control program; multi-programming and multi-processing.
- Advanced technology; reentrant code; recursive code; relocatable code.
- Program design; modularization; segmentation and paging; trade-offs such as between operating time and storage space.
- Software system design; compiler design.

If the total number of subject areas that we have listed above appears unreasonable, remember—it isn't! The list is a measure of what management will be expecting of the system analysts and programmers in the years just ahead. Specialization and separation of duties surely will occur, as one way of obtaining the needed knowledge within the data processing function. But the more effective system analyst will be the one who has a grasp of all of the subject areas listed, including awareness knowledge of the programming technology.

SOME PROS AND CONS

A number of objections to such a comprehensive training program can be expected. Here are some that we anticipate.

"We don't need to develop a training program. Our computer manufacturer will provide us with what we need." Companies that follow this approach find themselves becoming too dependent upon the computer manufacturer (which the computer manufacturer may look on as an assist to sales). The training reflects the computer manufacturer's bias on hardware, software and marketing policies. And the training provides little or nothing of the background material we discussed, or even much of the thorough grounding material. The training that is presented usually is very specifically related to job functions.

"We have too heavy a backlog of system analysis and programming work to undertake such a program. We can't spare our people off the job that much." As far as we have been able to observe, the data processing backlog never seems to get much better—and it usually gets worse. In such an environment, the avoidance of training now will only complicate the picture 2 to 4 years from now, when the trained people will be needed.

"Why provide employees with an 'awareness' training if it does not directly apply to their jobs? If they are interested in furthering themselves, let them do it on their own time." First of all, the employees *should* be expected to do some of their development on their own time. But proper training and upgrading requires a coordinated program—and some of the training will have to be presented on company time. If a company has a planned training program, some of which is based on courses available at local colleges or universities, then the employees will be more encouraged to take part in it.

"If we develop a good training program, we will just be raided and lose the people as soon as they are trained." This is a plausible argument. It indicates that the company should not do too much public bragging about its training program. But there is another side to the argument. A good training program can be an incentive for an employee to stay with a company—to get "that real interesting course that is going to start next month."

"The new applications packages will reduce the need for system analysts and programmers, and thus will reduce the need for training." Again, this is a plausible argument; still, these packages will not solve all of the company's system analysis, system design and installation problems. In particular, the application packages generally trail the technology. If a user wants to take advantage of a recent technological development, it is unlikely that he can use a package.

THE ADVANTAGES

The big advantage of a planned training program is that it can supply the needed people when they are needed. We are not optimistic about the ability of the established training agencies to supply the quantity and quality of needed

training in the next few years. Each using organization should expect to assume some of the burden.

The next big advantage is that a training program can widen the viewpoints of the system analysts and programmers. Data processing personnel—and particularly programmers—tend to develop too parochial a viewpoint. In a fast moving field, they must learn to adapt to change. They must learn how to undertake the broader, more challenging projects that lie just ahead.

A planned training program can be a real advantage both for recruiting data processing personnel and for holding on to current employees. Most data processing people want to be "in the know." If they are continually exposed to new ideas and developments via a training program, they will count this as a definite fringe benefit of their jobs.

In short, we see a planned training program—such as has been discussed in this report—as an essential element of a user's overall data processing efforts.

READING 25 DISCUSSION QUESTIONS

1 Describe the program needed to train systems analysts.

2 Describe the program needed to train programmers.

3 "We don't need to develop a training program because our computer manufacturer will provide us with what we need."

   (a) Discuss the shortcomings of this attitude.

   (b) Discuss three other possible objections to the training program outlined in this reading.

4 What are the advantages of the proposed training program?

READING 26 HUMAN FACTORS IN SYSTEMS DESIGN*

JAMES B. BOWER AND J. BRUCE SEFERT

The growing mechanization of data processing operations, particularly the automation brought about by the application of electronic computers, has intensified the human relations problems inherent in the design of business systems. As a result, business managers and systems analysts are devoting increased attention to the impact of the financial information system on the people within their organizations—and to that of the people on the financial information system.

Many trade unions, with some public support, have attacked automation as a leading cause of unemployment. There have even been proposals that automa-

*Reprinted from *Management Services,* vol. 2, pp. 39-50, November-December, 1965. Reprinted by permission from the American Institute of Certified Public Accountants, New York. Mr. Bower is a Professor and Mr. Sefert is an Instructor at the University of Wisconsin, Madison, Wis.

tion and data processing revisions be banned altogether.[1] The relation of automation to unemployment remains unclear. Congressional hearings have provided a sounding board for automation's opponents and proponents but no satisfactory answer.

Management opinion is divided as to the actual effect on employee wage levels, job security, advancement, and morale of the many changes that are taking place in both factory and office as a result of changes in procedures, work simplification, elimination of manual data handling, and the advent of high-speed communication. These changes are not confined to companies installing computers but are magnified and highlighted there.

Since systems changes involve people, they do not always have the same effects. Sometimes they are or seem to be beneficial to one or a group of the people involved; sometimes, harmful. Some studies of the effects of wholesale revampings of data processing methods have indicated that the employees were on the whole happy with their new jobs, that they generally benefited through higher wages, and that no hardship of any significant duration was visited upon anyone.[2] Other studies have reported employee disillusionment with the new jobs, the elimination of many promotion opportunities formerly available, complaints of being "chained to the machine," empire building by a new elite of EDP specialists, stagnation of middle management, and other adverse effects.[3]

In any case it is clear that there is need for extensive planning of every major procedural or data processing change. Provision should be made in advance to combat any possible harmful effects of systems change on the employees concerned and to take account in the systems design of the effect of human factors upon the operation of an economical and efficient system.

HUMAN FACTORS

The human factors principle of systems design, namely, that the design of a system should be consistent with applicable human factors since people are responsible for the effectiveness of the system, has been proved by experience to be a vital guide to the systems analyst in his work. The term human factors includes all those personality traits that consciously or unconsciously shape the actions and reactions of the people who must use the system as finally designed as well as those same traits reflected in the systems analyst himself as they may affect his ability to achieve an objectively efficient and successful design.

[1] *Automation and Unemployment,* Economic Research Department, Chamber of Commerce of the U.S., Washington, D.C. 1961, and William G. Caples, "Automation in Theory and Practice," *Business Topics,* Autumn, 1960, p.7.

[2] Einar Hardin, "The Reaction of Employees to Office Automation," *Monthly Labor Review,* September, 1960, p. 925.

[3] Albert A. Blum, "Electronic Data Processing and the Office Worker," *Data Processing,* June, 1961, p. 11; and Ida R. Hoos, "When the Computer Takes Over the Office, " *The Harvard Business Review,"* July, 1960, p. 102.

Only the more significant human traits can be explored here and those only as they affect systems design. Some factors, such as resistance to the new and strange, desire for job security, tendency to be influenced by the opinions of others, and preference for familiar work habits are basic in all employees at all levels but may apply with particular force or in particular ways with certain types of employees. Other factors become a problem only with certain groups.

For convenience in examining the effect of human factors on systems design, two levels of management are distinguished in this article. Top management consists of those executives who participate in companywide policy formulation, including the chief executive and those who report directly to him. The term middle management is used to encompass not only the usual group of middle and junior executives, such as division managers, department heads, and their staff functional advisers, but also operating supervisors and foremen since the human factors that affect this group as a whole are similar. Nonsupervisory employees are treated separately since their reactions to systems changes are usually different from those of people on the managerial levels. For purposes of this article the systems analyst is assumed to be either a member of a company's internal systems and procedures staff or an outside specialist in this field, who might represent an accounting or management consultant firm.

Some of the more important human factors that should be considered by the systems analyst in applying the human factors principle are illustrated in Figure 1. Unforeseen problems, including problems caused by human factors, often arise during the actual implementation of a new or revised financial information system, requiring adaptations. By taking as many human factors as possible into account during the planning of the system, however, the analyst improves his chances of producing an efficient, well accepted system with few subsequent revisions.

In the discussion that follows the components of the human factors principle are applied in detail to each of the three levels of personnel previously identified.

TOP MANAGEMENT

It is axiomatic that the wholehearted support of top management is required for systems acceptance and success. Middle management and nonsupervisory employees are quick to take their cue from the attitudes that flow downward. In the past, top management often viewed work procedures and systems study as a specialized function worthy of its attention only when a crisis arose. With the advent of computers, which are often so costly as to require justification to boards of directors or stockholders and which have been so heavily publicized as to become status symbols, top management has become much more involved in the problems of data processing.

This is fortunate, for continued top management attention is vital to the eventual success of any system. At several points during the systems project top

FIGURE 1 FOCUSING ON HUMAN FACTORS

System design — Analysis—synthesis—implementation and follow-up

Human factors

Top management

- Prior interest in procedures
- Company patterns of change
- Status symbols as motive for change
- Courage to carry through change
- Willingness to assign best people to system team
- Tendency to patchwork solutions
- Concern for human relations
- Isolation of top executives
- Tendency toward secrecy
- Interest in details of procedures
- Attitude toward delegation of authority
- Strength of interest in change
- Resistance to organizational change
- Attitude toward employee ideas
- Willingness to use new tools and skills
- Ability to adjust and learn
- Attitude toward training needs of employees
- Impatience with rate of progress
- Breadth of management goals
- Promptness in making decisions

Middle management

- Prior participation in problem solving
- Tendency to concentrate on technical aspects of jobs
- Attitude toward staff specialists
- Fear of replacement by young workers
- Willingness to work for deferred goals
- Need for visible evidence of production
- Lack of job mobility
- Need for guidance and approval from others
- Emotional barriers across departmental lines
- Desire to air views and participate
- Need for reassurance of importance of job
- Worry about ability to learn and supervise new procedures
- Pride in status symbols of position
- Past experience in making suggestions
- Fear of becoming mere machine monitors
- Tendency to blame system for errors
- Irritation at too-rapid changes
- Resistance to rigid work schedules
- Fatigue and pressure during systems change
- Fear of loss of promotional opportunity

Nonsupervisory employees

- Resistance to the new and strange
- Fear of machines
- Tendency to believe rumor vs. fact
- Need for reassurance as to job security
- Trust in management
- Pride in company progress
- Need for group motivation
- Desire for affection, recognition, attention
- Tendency to short-range goals
- Desire to know reasons for change
- Need to identify with problem
- Tendency to question company motives
- Response to opportunity to participate
- Need for activity and visible product
- Passive resistance of affected groups
- Fear of loss of respect for specialty
- Resistance to inflexibility of machines
- Influence of key workers
- Dislike for more rigid work pace
- Tendency to accentuate shortcomings of system
- Instinct for self-protection from blame
- Need for well defined goals and objectives
- Faith in company promises

management must review interim findings and approve or disapprove recommendations for further action. Careful consideration and prompt decisions are essential.

Mere interest and support from top management is not the whole answer, however. The analyst must take account of many human factors at this level in determining management's information needs, in alerting top executives to the full implications of any large-scale revision in the data processing system, and in making sure that executives are aware of and capable of obtaining the full range of benefits available.

COMPANY PATTERNS Most established companies have certain patterns of activity that affect their approach to innovations. One systems analyst has likened these patterns to the rituals of a South Seas tribe, complete with dances to drive out evil spirits.[4]

In some organizations duties and responsibilities are well defined; many small, closely knit companies prefer a freer, looser structure.[5] Some managers are direct and forceful in ordering changes; others prefer devious and indirect methods. Some top managements are simply not prepared to make any substantial changes in the organization or in methods of operation. In such situations the systems analyst must decide whether to adapt the system to accommodate the attitude or to try to change the attitude.

The pattern of change in a company may have been molded by special factors that operated in the past. A top executive may feel that he holds his present position because of some procedure or method he introduced many years ago; he is not likely to welcome any change.[6] Special care should be taken to see that the new system, instead of endangering this executive's sense of value to the company, can be identified with his contribution as an outgrowth of it. Another top manager may have a pet project to which he gives special attention and which is part of his personal pattern of self-esteem. The analyst must always be alert to avoid colliding with such "sacred cows."[7]

Individual personalities are important, too. One executive may be a so-called detail man who likes to have a hand in designing procedures himself. Another may be an idea man interested only in the broader aspects of the system or a results man interested only in end objectives. In each case the analyst must adapt his approach accordingly.

If the company has a history of orderly and considered attention to continued improvement rather than one of patchwork solutions to immediate crises, the

[4] Allen Y. Davis, "Gaining Acceptance of New Ideas," *Ideas for Management—1959*, Systems and Procedures Association, Detroit, 1959, p. 219.

[5] Keith Davis, *Human Relations in Business*, McGraw-Hill Book Company, Inc., New York, 1957.

[6] "Computers," *Business Week*, June 21, 1958, p. 68.

[7] Abner W. Boyd, "Human Relations in System Changes," *N.A.A. Bulletin*, Vol. 40, July 1959, p. 69.

nalyst can conclude that the top management is likely to be systems-oriented nd ready to support him in designing and installing a new system.

MANAGEMENT CLIMATE Companies that show sincere concern for the mployee as a human being build up an employee trust in top management that s of great value in gaining acceptance of change. If management has been willing n the past to use employees' ideas, imagination, and suggestions and to pay ttention to workers' feelings in visible ways, the systems analyst's task will be ased considerably

He should, therefore, appraise the management climate of the organization as arly as possible so that he can take it into account in systems planning. If he inds a climate of teamwork and understanding among departments, delegation of authority by management, and stimulation of the challenge of problem solving, he can devote his primary attention to technical problems. If he finds a climate of top management isolation, rigid departmental barriers, little or no downward communication, and reluctance to keep employees informed of company plans and policies, he may need to educate top management about the mportance of attention to people in assuring the success of any proposed new system.

An aspect of management climate that has particular significance for the systems analyst is the extent to which authority has been delegated to lower evels. If all decisions have traditionally been made from above, the analyst is ikely to find managers and employees alike hesitant to make suggestions and express opinions; their ideas have dried up from lack of encouragement.[8] In such a situation top management needs to give visible evidence of its support of the systems project. It should, for example, select capable representatives from the departments that will be affected by the systems study to help the analyst with it, and it should give them the time and authority needed to do a proper job.

A detailed study of fundamental systems changes made over a five-year period in a large electric utility[9] provides a striking example of the way in which differences in prior participation in planning and problem solving can affect departments' contribution to and acceptance of change. In the accounting department much effort had been spent over the years in developing participation management by intermediate and first-line supervisors. The result was a high degree of employee satisfaction, trust, and good will, which proved very valuable during the transition from one system to another. In the sales department, for a variety of reasons, the employees had never participated in management to this degree. Furthermore, this pattern continued during the

[8] Dr. Thomas J. Mallinson, "Human Relations," *Ideas for Management– 1960,* Systems and Procedures Association, Detroit, 1960, p. 234.

[9] Floyd C. Mann and Lawrence K. Williams, "Observations on the Dynamics of Change to Electronic Data-Processing Equipment," *Administrative Science Quarterly,* September, 1960, p. 217.

systems changeover. Communication of information about the change was much less complete at all levels than in the accounting department. No attempt was made to present the new system to the sales employees in relation to their special interests and objectives. As a result, the sales employees never understood the system as well as the accounting employees, had less confidence in it, and presented more difficult problems during the transition.

As recent experience with large-scale computer installations has demonstrated, employee acceptance of change depends heavily on top management's willingness to make assurances about job security, salary retention, opportunity for training, and rules to be followed in reassignment.[10] As the plans for a major systems change unfold, top management will have to chart its course of action in the field of human relations.

What attitude should it adopt toward displaced labor? Is it willing to assure to all affected employees the opportunity for continued employment regardless of the changes in data processing methods and departmental and individual functions? Is it willing to bear the expense of retraining employees? Will it show concern for the employees' self-respect and personal improvement during periods of change and at other times?[11]

Although these decisions are not the systems analyst's to make, he cannot—and should not—avoid some involvement in them. He has a responsibility to take account in his planning of any provision for utilization of present employees, their training and retraining, and their job mobility. He should, therefore, press for early top management decisions on these points.

In fact, the analyst's ability to obtain prompt policy decisions from top management on all questions that arise throughout the study will be an important factor in the success of his work. Procrastination in making difficult decisions is a basic human trait. The systems analyst must press firmly for such decisions while using every means available to demonstrate the logical basis of his proposals. In one manufacturing company the systems and procedures staff personnel were forced to spend 60 per cent of their time on attempts to obtain final decisions. In the words of one staff member, attempting to get a decision was "like trying to tie a rope around a pile of sand."[12]

Decisions will be particularly difficult to get if a basic change in organizational structure is required or if the proposed change will create an embarrassing personnel problem. If the organizational pattern of the company has tended to develop around personalities rather than being based upon logical division of functions, the difficulties of change will be magnified. If top management is

[10]Ben Conway and Duane E. Watts, "Putting Electronic Data Processing to Work," *The Price Waterhouse Review,* Vol. 3, September, 1958, p. 19.

[11]"Human Side of Enterprise," *Factory,* Vol. 118, August, 1960, p. 84.

[12]Richard F. Neuschel, *Management by System,* McGraw-Hill Book Company, Inc., New York, 1960.

adamant in refusing to make an indicated organizational or personnel change, the systems analyst may have to build around the existing structure or person, recognizing that a good system that has the support of management is to be preferred to the best system if the latter will not be supported or used.[13]

DESIRE FOR IMPROVEMENT If the systems analyst finds that top management has a genuine desire to solve any systems problem discovered to exist, it is likely that he will also find the desire and courage to make the changes necessary to implement the solution.

Top management's willingness to assign good people to work with the analyst and to give him the necessary time and responsibility is one test of its real interest and concern. Too often the tendency has been to make such assignments on the basis of availability rather than suitability. If management shows such a tendency, the analyst needs to point out the importance of having outstanding people on the planning group and the benefits to be expected.

The use of a project team made up of representatives of the various departments affected, operating with or under the analyst, may be a new problem solving procedure in the company. It has, however, many advantages. Not only does it usually produce a sounder system design but it also greatly facilitates acceptance of the system, both by the members of the team and by others. The representatives of the personnel and industrial relations departments can help in determining the human relations climate of the organization and in helping to plan the final proposals regarding employee utilization. The representatives of the operating departments can be useful in alerting the analyst to any special human factors problems that may arise in their areas.

The strength of top management's desire for improvement will be further tested as it is informed of the training time and costs of installation that will probably be involved in any large-scale systems revision. A realistic appraisal of such factors during the planning phase of the systems project will give management an opportunity to determine its step-by-step involvement.

If cost cutting has been the principal factor in top management's motive for change, it may be desirable for the analyst to reorient management toward the goal of labor saving in the broadest sense, that is, the use of saved labor to make possible improved and faster information for decision making. A system that provides better tools for management is more valuable over the long run than one that simply reduces costs. This shift in emphasis toward a broader goal also will help to ease the fears of operating personnel about labor displacement.[14]

[13] N. C. Pollock, "The Systems Function," *Ideas for Management—1959,* Systems and Procedures Association, Detroit, 1959, p. 185.

[14] Virgil F. Blank, "The Management Concept in Electronic Systems," *The Journal of Accountancy,* January, 1961, p. 59; and Harold Koontz, "Top Management Takes a Second Look at Electronic Data Processing," *Business Horizons,* Spring, 1959, p. 74.

The systems analyst bears much of the responsibility for educating top management about systems in general and about his system in particular. He should do what he can to help management understand what the system can provide and how it can be of value in planning and decision making. At the same time he should be laying the groundwork for further systems advances. The managers of tomorrow must have a broad knowledge of the interdependence of all parts of the business and the potential for improving decision making offered by the increased variety of information made possible by a modern data system. The systems analyst can play a vital role in top management's data processing education.

MIDDLE MANAGEMENT

An understanding of the human factors at work in the middle management group of managers and supervisors is especially important to the systems analyst. The personnel at this level hold the key to success or failure of a new system. Top management relies on them for the organization's everyday efficiency and smooth operation; the nonsupervisory employees take their direction and set their course from them. The systems analyst has traditionally found it necessary to work closely with middle management. In systems analysis he must depend heavily on the information they furnish; in systems implementation and follow-up he needs their acceptance and cooperation.

PROBLEMS Middle management presents a number of special problems for the systems analyst. Typically, managers below the top management group and supervisors have a narrow perspective on company operations. They are so immersed in their own jobs and their own departments that they cannot see the significance of what is going on elsewhere in the company. The systems analyst will have to devote considerable educational effort to the task of building up in the middle managers a feeling for the total job that is being attempted.

Typically, too, middle managers concentrate their attention on the technical rather than on the administrative and human relations aspects of their work. Thus, the analyst will need to keep emphasizing to them the importance of teaching the new system to the employees under them and the need for selling the system to the workers.

Another human factor that is important at the middle management level is the increased resistance to change that accompanies increased age. This resistance is likely to be especially intense in large and stable organizations. Age increases resistance to change partly because of growing reluctance to alter familiar and comfortable established work patterns and partly from the ever-present fear of inability to compete with younger people in the organization. This resistance is partly unconscious. There is an instinctive tendency to organize experience in a

manner that will be minimally threatening and to believe what one wants to believe.[15]

Furthermore, middle managers are consciously fearful of automation. Any substantial reduction in the number of employees is likely to reduce the number of supervisors needed as well. Forecasts that the computer, by taking over routine decision making, will wipe out middle management have been highly publicized. Certainly the inflexibility of programs necessary to ensure uniform input, processing, and output in a large-scale computer system changes the scope of middle management decision making. This may, as some claim, leave the manager free for higher activities, but some middle managers are understandably skeptical.

As with any other employee group, middle management's past experience with systems change is a powerful determinant of its current attitude. A manager whose last experience with a staff specialist was unfortunate may be convinced that all staff men are arrogant, impractical, and opinionated and that it is a waste of time to deal with them. Perhaps he once suggested an improvement that was not acknowledged or that was adopted without credit. If so, he is probably still nurturing his hurt feelings. The systems analyst will have to dig out such attitudes and convince the supervisor that suggestions will be welcomed and used.[16]

Past experience also, although unfortunately less frequently, can be a help. If earlier systems analysts have dealt with middle managers successfully—and particularly if top management has made a practice of encouraging middle management participation in problem solving and decision making—the systems analyst will find his path easier.

One advantageous characteristic of middle managers is that they are usually accustomed to working toward long-range goals, such as promotion, retirement, and education of their children. Thus, they do not need evidence that a change will bring them immediate benefits to the extent that lower-level employees do.

PRELIMINARY STUDY Even before the study has actually begun, the systems analyst will need to be at work allaying the fears of middle management and employees alike. In any organization it is difficult to get ahead of the rumor network. As early as possible top management should make a definitive announcement of the scope of the study. If this announcement can also contain assurances of job security and other measures for employment stabilization, so much the better. In case top management does not recognize the importance of informing employees early, the systems analyst should consider it his responsibility to point out the need for such announcements and recommend their

[15] Donald N. Michael, "The Social Environment," *Operations Research,* Vol. 7, July, 1959, p. 506.

[16] Philip E. Wheatley, "The Human Element in Systems Surveys," *Systems and Procedures,* May, 1960, p. 33; and "Change Requires Employee Support," *Nation's Business,* August, 1959, p. 33.

timing and content. Reasons for the change should be stated, with emphasis upon the broader goals and the benefits to be derived by everyone. If possible, better use of labor rather than cost reduction should be stressed. Some companies planning computer installations have given employees as much as three years' notice of impending changes in order to accustom them to the idea.

Subsequent interim reports are also desirable. These should be as specific and factual as possible and should continue to stress positive benefits. Middle management in particular needs to be kept continuously informed so that it can answer questions from employees and interpret to them the aims and policies of top management.

ANALYSIS PHASE The analysis phase of the study, when the systems analyst is gathering information on current procedures and work flows by interviewing middle managers and employees, gives the analyst one of his best opportunities to obtain supervisory cooperation and reduce supervisory fears.

The middle manager's fear of loss of self-esteem and status can be countered by stressing the increased importance of each manager or supervisor through his part in supplying better information for decision making. The increased need for the manager as a trainer of personnel can be emphasized as an offset to any dimunition of his personal responsibility for decision making.

Middle managers will be anxious about possible decreases in employment and the effect on them. The systems analyst can reiterate any assurances previously given by top management as to job security, displacement policies, and retraining and can explain probable new positions and their duties. More generally, he can point out that studies of current employment trends indicate that the number of professional and technical workers will increase more than 40 per cent over the next decade and that the number in clerical and sales occupations will increase by 30 per cent.[17] He must be careful, however, not to promise upgrading to any specific manager.

Managers and supervisors may be worried about their ability to learn new techniques and keep ahead of their subordinates. Many will doubt their ability to supervise under the new methods. The systems analyst can cite the experience of other companies installing automated data processing systems to show that many persons over 45 have been trained to fill technical positions in the computer field, often more rapidly than younger persons could be trained. These companies have found that older employees' greater sense of responsibility, their reliability, their care for details, and their mature judgment have made such a policy advantageous.[18]

[17] Louis F. Buckley, "1960 Manpower Trends and Automation's Impact," *Commercial and Financial Chronicle,* August 18, 1960, p. 660.

[18] *Adjustments to the Introduction of Office Automation,* U.S. Dept. of Labor Bulletin No. 1276, Washington, D.C., 1960.

More generally, the systems analyst can build up the middle manager's confidence by treating him as an intelligent equal, competent to understand the system and its problems. The analyst should avoid all signs of condescension or any implication that there is the slightest question about the supervisor's ability to handle any situation that may arise.

In addition to allaying middle management's fears, the analyst should attempt to build positive support for the new system. If the supervisor is given an opportunity to air his views on the present system and take part in the planning for improvement, he will become interested in the ultimate success of the new procedures. The analyst should recognize the supervisor's experience and remember to be a good listener. Whenever appropriate, he should visibly record suggestions so that credit can be given for them if they are adopted.[19] And he should stress middle and top management's common interest in building the best possible system. Often it may be wise to interview the supervisor away from the office atmosphere to keep work pressures from interfering with his objective consideration of new ideas and to ensure that he will be free to discuss controversial aspects of the present and proposed systems.

The systems analyst's approach has been likened to that of a doctor whose objective is essentially preservative. He should adopt the view that the organization is basically sound and healthy and that he is not there to tinker for the sake of tinkering. In this way he will impress the supervisor with his concern for people and their problems and his willingness to conserve ideas that have survival value.

IMPLEMENTATION Other problems arise during implementation of the system. When possible, the analyst should anticipate these problems and do what he can in the planning stage to minimize or offset them.

One source of job dissatisfaction for workers and supervisors alike after the installation of automated systems is the lack of visible evidence of the product of their labor. Workers have a basic need to see that their jobs are significant. A series of entries, a list prepared, a report are all visible evidence of accomplishment. Closely related is the feeling that to be producing one must be doing. In many new systems supervisors and workers see no end product of their work, nor is the work itself highly visible. This trend is likely to continue.

The only solution for the systems analyst is to begin educating middle management to other job satisfactions as early in the systems project as possible. This will not be easy since these other satisfactions tend to be more abstract than the old. The analyst also should remind supervisors that they will have to plan to give more attention to worker morale and develop new methods of praise

[19] John M. Emery, "Systems and Procedures Development," *Journal of Machine Accounting,* December, 1959, p. 12.

and reward. Most middle managers will need training in human relations, and the analyst should make certain that such training is provided.

The relatively greater inflexibility of highly integrated data processing systems will create problems for middle management. Because of the interdependence of parts of the system, the supervisor will be blamed for delays further down the line. He will be subject to greater pressure for adherence to higher work standards, and he will find that improved feedback will pinpoint responsibility more surely than before.[20] If he is caught off guard by these changes, he may become resentful and resistant—and transmit this feeling to his subordinates. The systems analyst can forestall these reactions by holding briefing sessions with both supervisors and employees and by meeting regularly with individual supervisors during and after the system implementation to check on their reactions and on the morale of their employees.

Unreasonable deadlines can provoke resentment in both supervisors and employees. The analyst should work with top management to keep deadlines realistic. If it becomes evident that the deadlines set cannot be met through no fault of the supervisors or employees, he should relieve their anxiety by assuring them that no blame attaches to them.

During the entire systems design period middle management's work load will be increased. Learning new procedures, training employees, being interviewed, attending meetings, and supervising two parallel work processing systems during testing periods can combine to create tremendous pressure on middle management, pressures that are not conducive to a kindly feeling toward any new system. By careful preplanning the analyst should attempt to minimize these pressures so far as is possible.

It is just as important for the systems analyst to enlist the understanding and support of the rank-and-file employees as of the managers. A group of nonsupervisory workers can sabotage a system they do not accept just as effectively as a supervisor can. In fact, their sabotage may be even more difficult to combat since it may be more subtly applied through group action.

Although the basic human factors that affect the nonsupervisory employee are the same as those that operate at the top and middle management levels, his different position in the organization and normal lack of contact with top management plans and policies lends added weight to some of them. For example, because nonsupervisory workers, particularly younger ones, tend to have shorter-range goals than management, it is difficult to sell them change based upon some abstract general benefit. They demand an immediate personal advantage.

The nonsupervisory employee is generally more group-oriented and less of an individualist than the manager. He is more susceptible to rumors and to the

[20] G. H. Cowperthwaite, "The Challenge of Mechanization," *Systems and Procedures,* May, 1960, p. 20.

ıfluence of his fellow-workers' opinions. Other human factors that are articularly important at the nonsupervisory level include the desire to produce visible product as evidence of work accomplished; a need for recognition, ffection, and attention; the importance of status in the eyes of co-workers, riends, and family; a need for activity in work as contrasted with the relative nactivity of merely monitoring a machine; the need to lean on others for upport and encouragement; and the social need for working in groups. utomation is making the worker more isolated at his work place at the same ime that there seems to be a growing number of other-directed persons in our ulture who look to others for guidelines and approval.

The basic instinct of resistance to the new, strange, and unknown is intensified n human fear of machinery as a displacer of labor. Recurrent periods of nemployment help to keep this fear alive. Automation seems to have replaced he loom and steam engine of the early Industrial Revolution as the public and rade union symbol of danger from impersonal forces outside the worker's ontrol.

The systems analyst cannot completely prevent the operation of these basic uman factors. It will take a long time to substitute new values and new job atisfactions. If, however, he is aware of these forces at work, he may be able to ffset them or at least minimize their effects by proper training and by ntroducing contrary forces.

Even the employee who would admit the desirability of proposed systems hanges if he were capable of being objective is likely to develop a core of assive resistance under the influence of his fears and his fellow-workers. The ystems analyst must exert continuous positive pressure to overcome this endency.[21]

The importance of keeping the employees informed has already been stressed. he inevitability of rumors negates the theory that information which might pset the employees should be withheld. They will be upset anyway, and they eed reassurance as to their job security, opportunities under the new system, nd steps to be followed during the changeover. In addition to the usual neetings, bulletins, and newsletters, the union may sometimes be used as an ffective channel of communication.

Many of the employees the analyst interviews will question the real motives of he company in making the changes. The analyst can break down this skepticism y relating the company's general systems problems to each individual's own vork experience, thus demonstrating the need for improvement. Often it is wise o devote extra effort to convincing the opinion leaders within employee roups so that they in turn can become salesmen to their fellow-employees. Such mployees should be given opportunities to air their views, and the analyst

[21] Edwin S. Raub, "Applied Psychology for the Systems Man," *Systems and Procedures*, April, 1961, p. 23.

should return to them for further suggestions as the project develops. The analyst must be careful to sell the ideas on their own merit rather than by mere personality; there should, of course, be no misrepresentation.

To counteract employee fear of loss of status, the analyst can emphasize the new job values, which will place a premium on responsibility. He can encourage employees to apply for new positions as they open up. By showing genuine interest in the individuals he is interviewing, the analyst can do much to boost employee morale and build confidence.

As with middle managers, nonsupervisory employees should be prepared for the greater rigidity of mechanical equipment and the importance of interdepartmental teamwork in keeping the work flowing. The analyst should emphasize the importance of adherence to work standards, both to keep the employee on his toes and to keep him from blaming breakdowns on "the system" rather than on human errors. Any tendency to blame the system for errors can create serious operating problems by undermining confidence in the system and thus encouraging the human tendency to create additional records as protection against possible blame for error. The plan for system implementation should include provision for continuous checking by the analyst to uncover possible sources of breakdown and eliminate trouble spots promptly.

Another systems design technique that is helpful in preventing breakdowns is to build some flexibility for limited self-adjustment into the system. Allowing affected departments to adjust for unforeseen contingencies without having to wait for a formal systems change prevents irritants from growing and gives both employees and supervisors a sense of identification with the system.

THE ANALYST HIMSELF

As a human being, the systems analyst is, of course, subject to some of the same human factors that operate in managers and employees—and to some of his own. When given an opportunity to comment, employees have variously accused systems men of demonstrating a narrow perspective, of having a tendency toward isolation, of talking in language incomprehensible to the ordinary person, of cutting across lines of authority, of empire building, and of stirring up jurisdictional disputes. Some analysts have given the impression of automatically opposing any methods in use before they arrived on the scene, setting themselves almost by instinct against the old to favor the new.

The advent of electronic data processing and the necessity of combining on management and operating teams persons of technical training and scientific background with those having only operating experience have compounded the problems of human relations in the systems field. Often the specialized personnel are accused by the others of setting themselves apart from the regular organization, of adopting a tough attitude, and of seeming to feel that human frailties are a nuisance best avoided by adding equipment.

The natural suspicion that an expert arouses when he comes into a department
begin an analysis of work flows and procedures makes it all the more
nportant for him to establish cooperative relationships as quickly as possible.
mong the more desirable qualities in a systems analyst are humility, a
ealization that his mission is one of service, not an end in itself, and a genuine
nterest in people. He should be a good listener, willing to accept suggestions,
nalyze them objectively, and give due credit for any ideas adopted. Giving
redit for an idea to the person whose acceptance of it is sought can have a
rong influence on the employee's interpretation of the situation.[22]

The systems analyst's awareness of the problems that human factors can cause
or him in his work makes it all the more important for him to analyze his own
nethods critically to see whether any of the difficulties he may be encountering
obtaining cooperation and acceptance from employees may stem from his
wn failure to practice good human relations. Like Caesar's wife, he should
e above reproach.

EADING 26 DISCUSSION QUESTIONS

What are some of the human factors operating at the top management level?

What effect does the management climate of an organization have on the prospects for successful change?

"Middle management presents a number of special problems for the systems analyst." Discuss these problems.

What techniques can be used to secure the cooperation of middle managers?

Identify and discuss the human factors important at the nonsupervisory level.

UMMARY OF CHAPTER 6

efore the conversion to electronic processing systems can be made in a way
vhich will satisfactorily achieve company goals, attention must be given to the
taffing function.

Plans must be made to recruit and select personnel to fill the new positions
vhich computer usage will create. A prerequisite to sound recruitment and
election is the preparation of job descriptions and job specifications. New jobs
nay be filled from a pool of present employees or from candidates recruited
rom external sources. Most businesses have found that when suitable employee
andidates are available it is preferable to give them the necessary training to

[2] Robert E. Schlosser, "Psychology for the Systems Analyst," *Management Services,* November-December, 1964, p. 34.

prepare them for the new positions. However, when suitable candidates are not available internally, the company must resort to external sources. Workers are usually selected on the basis of aptitude test scores, personal interviews, and background records.

The most extensive training during the preparation period must be given to analysts and programmers. Richard G. Canning's reading presents a suggested program to provide this training. It is also desirable that noncomputer personnel receive exposure to data-processing concepts. Training given for operators of peripheral equipment may consist of short formal classes combined with on-the-job training, or on-the-job training alone.

Resistance to the change to electronic data processing is the rule rather than the exception. This resistance may appear in many forms when employees perceive that the change threatens the satisfaction of certain personal needs. Resistance may come from all employee levels—from clerks to vice-presidents. But by knowing and following certain guidelines and suggestions with care, the changers may be able to reduce the level of opposition.

If jobs are to be eliminated or changed, executives should plan at an early date to reduce the personnel hardships which can occur. Although technological change is desirable for the nation as a whole, the effects of displacement on particular individuals can be serious. Business, government, and labor leaders must make every effort to see that displacement does not cause an individual to be involuntarily thrown out of work.

CONTROL AND THE COMPUTER

In this chapter we consider two aspects of the subject of control and the computer. *First*, we shall briefly review some ways in which information produced by computer systems *can help managers control business operations*. Of course, if managers are to perform this function of the management process satisfactorily, the information upon which control decisions are based must be of high quality. Therefore, the *second* major consideration in this chapter will be the examination of the *controls which are applied to processing techniques and procedures* in order to produce a high-quality information output. More specifically, the topics covered in connection with this second consideration are *internal control, administrative controls,* and *data controls*.

MANAGERIAL CONTROL: A SYNOPSIS

The control function of the management process is a follow-up to planning activities—i.e., it is the check on current performance to determine if planned goals are being achieved. Thus, control activities are involved in the day-to-day administration of a business. You will recall that the general control procedure consists of several steps: (1) the establishment of predetermined goals or standards; (2) the measurement of performance; (3) the comparison of actual performance with the standards; and (4) the making of appropriate control decisions.

The information output of the computer can help the manager carry out this procedure in many ways. First of all, better information about such things as the effectiveness of the firm's sales and distribution efforts, the quality and cost of the firm's products and services, and the strengths and weaknesses of the company's financial position can lead to better planning and to the creation of *more realistic standards.* Computer simulation can assist managers in setting goals by showing them the effects of various alternate decisions when certain conditions are assumed; and computer-based network models such as PERT and

CPM can improve planning (and therefore control) by forcing managers to identify all project activities which must be performed.

Computer processing systems can also help managers control by gathering, classifying, calculating, and summarizing *actual performance data* promptly and accurately. Once performance data are read into the computer, it is possible for the machine to *compare* the actual performance with the established standards. Periodic reports showing this comparison can be prepared; in some systems, triggered reports may be furnished to the manager only when variations are outside certain specified limits.

It is also possible to program the computer so that it signals when *predetermined decisions* should be carried out. For example, a program may specify that when the inventory of a certain basic part falls below a given level, an output message signals the need to reorder and indicates the reorder quantity. By thus relieving man of many of the routine operational control tasks, the computer frees him to devote more time (1) to planning future business moves and (2) to leading the all-important human resources of the organization. Such a man-machine relationship, in other words, makes it possible for man to concentrate more of his attention on the heuristic area of intellectual work—an area in which he is far superior to the machine—while the machine is permitted to take over the well-structured control tasks.

Of course, an assumption underlying everything said in the above paragraphs is that the *information produced* by the computer system *is of high quality.*[1] If it is, total business operations may be well controlled; if it isn't, inadequate managerial performance may be expected. Internal control arrangements are therefore needed to assure managers that accurate and proper information is being produced by the computer.

INTERNAL CONTROL

Internal control is the total of all the control arrangements adopted within an organization to (1) check on and maintain the accuracy of business data; (2) safeguard the company assets against fraud and other irregularities; (3) promote operating efficiency; and (4) encourage compliance with existing company policies and procedures.[2]

[1] You may wish to review the desired properties of quality information presented in Chap. 1.

[2] This definition is based on the one prepared by the American Institute of Certified Public Accountants. See *Auditing Standards and Procedures,* Statements on Auditing Procedure, no. 33, AICPA, 1963, p. 27.

NEED FOR INTERNAL CONTROL

In noncomputer systems the data-processing activities are typically separated into several departments with a number of employees being responsible for some portion of the total activity. For example, in the processing of a customer order, credit approval may come from one location, control of the inventory of ordered items may reside in another department, customer billing may be handled by a third department, and receipt of payment for items shipped may be in a fourth location. Thus, the organizational structure separates those who authorize and initiate the order from those who record and carry out the transaction. And both of these groups are separated from those who receive payment for the order. Such a division of data-processing activities makes it difficult for fraud to go undetected, since several people from different departments would have to be a party to any deception. Also, personnel in each organizational unit can check on the accuracy of others in the course of their routine operations.

But as Chapter 5 pointed out, the tendency is for data-processing *activities to be centralized* as a result of computer usage. Centralization of activities, along with greater integration of processing steps, may make it possible for a single department to perform all the steps required to process a customer order. In the past, internal control has been achieved by the reviews and cross-checks made by personnel at separate points in the organizational structure. In other words, *internal control was employee oriented.* With fewer departments involved, however, and with the likelihood that fewer people are cross-checking data, it *may appear* that, even though source documents originate outside the computer department, the use of computer systems results in a reduction of internal control.

Such a reduction *can occur* in an inadequately controlled centralized computer department.[3] But there is no reason why a company *should* have less internal control because of computer usage. On the contrary, there is no reason why *systems-oriented controls,* in the form of computer programs, cannot be substituted for employee-oriented controls; and there is no reason why the separation of duties and responsibilities cannot be maintained *within* the computer department to safeguard the integrity of the systems-oriented controls. In fact, there is no reason why a firm cannot achieve better control because of (1) the computer's ability to follow policies and execute processing procedures uniformly, (2) the difficulty of changing and manipulating, without detection, proper programmed systems controls, and (3) the computer's inherent accuracy advantage when given correct input data.

[3] For verification of this point, see Sheldon Dansiger's interesting "Embezzling Primer" at the end of this chapter.

ORGANIZATION AND INTERNAL CONTROL[4]

Separation of activities *within* the computer department can help maintain the integrity of systems-oriented controls. One important control principle is that there should be an organizational separation between those who design and prepare the new systems and those who prepare the input data and operate the equipment. In other words, analysts and programmers should design, maintain, and make necessary changes (according to specified procedures) on programs, but they *should not* be involved with day-to-day production runs; equipment operators, on the other hand, should not have unrestricted access to completed computer programs, nor should they be involved with making changes in data or programs. Completed programs and their supporting documents should be kept and controlled by a librarian who is not engaged either in planning or maintaining programs or in operating processing equipment. These programs and documents should be issued to interested parties only upon proper authorization.

AUDITING AND INTERNAL CONTROL

Business information systems undergo periodic examinations or *audits* by *internal auditors* (employees of the firm) and by *external auditors* (independent certified public accountants employed by the board of directors or stockholders). The evaluation of internal control arrangements is the point of departure in auditing. Although no exact audit procedure is used, the auditors seek to determine, by observation, inquiry, and review of charts and manuals (1) whether a proper organizational separation of duties has been made and (2) whether adequate controls have been created to maintain accuracy, safeguard assets, etc.

During the course of the examination, attention is turned to the *audit trail* to determine if controls are effective and if reported procedures and policies are being followed. The audit trail begins with the recording of a transaction, winds through the processing steps and through any intermediate records which may exist and be affected, and ends with the production of output reports and records. By selecting a representative sample of previously processed source documents and by following the audit trail, the auditor can trace these documents through the data-processing systems to their final report or record destinations as a means of testing the adequacy of systems procedures and controls. In a manual system, original transactions may be recorded in one or more books of original entry; from there they may be connected to the final output by means of ledgers, documents, and summary totals. A visual and readily traceable trail is thus created.

[4] For more details on this important subject, see Michael Moore's article entitled "EDP Audits: A Systems Approach," at the end of this chapter.

With the introduction of computer systems, however, the *form* of the trail has changed. Of course, *it cannot be eliminated* because of the desire for good internal control and because of tax and legal requirements. The Internal Revenue Service, in a 1964 report on the use of EDP equipment, said that ". . . the audit trail or the ability to trace a transaction from the general ledger back to its source document must not be eliminated."[5] Nevertheless, intermediate steps in the information systems which were previously visible *have seemed to vanish* into reels of magnetic tape, into magnetic disks, and into magnetic cards and strips. To those auditors not familiar with computer systems, a portion of the audit trail "disappeared" at the entrance to the computer site. Since a "lost" audit trail is naturally a serious control matter, accounting literature is full of articles on this subject.

Nor will the audit trail become more visible in the future. The increased use of online direct-access storage devices to hold intermediate data and the substitution of online processing techniques for batch processing will result in an even greater decrease in the visible portion of the trail. For example, source documents may be replaced by machine-language recordings made with transaction recording equipment; input data will originate from widely dispersed locations through the use of remote terminals (again, no paper documents need be involved); and a reorder message for a basic part may be transmitted by the computer to the supplier through the use of data-communications facilities with no paper documents being prepared. In examining such systems, the auditor must be satisfied that adequate controls are incorporated to prevent unintentional or deliberate damage to "invisible" files and records stored in an erasable medium.

In a majority of the past electronic systems audits which have been made, the "around-the-computer" approach has been used.[6] In this approach, the assumption is that if the input data to the computer are correct and if the output is properly handled, then the intermediate processing must be correct. This approach owes much of its popularity to its simplicity and familiarity to the auditor. An alternative is the "through-the-computer" approach,[7] where the auditor verifies (1) that the input data are correct and (2) that internal processing is properly conducted. He then assumes that output is correct. The around-the-computer approach may be suitable for audits made during the initial

[5] See Benton Warder, "An Auditor Looks at Data Processing," *Journal of Data Management,* vol. 5, p. 17, February, 1967.

[6] The expression "auditing around the computer" may carry the implication that the auditor can ignore the machine. This, of course, is false. The expression is used here because it has appeared extensively in accounting literature. See Gordon Davis's article entitled "The Auditor and the Computer," at the end of this chapter.

[7] Several different techniques and tests have been developed for this approach. See Moore's discussion of this topic in his article at the end of this chapter.

phases of a computer changeover and for some low-volume, uncomplicated systems; the through-the-computer method is frequently preferable for larger, more sophisticated procedures. Many auditing authorities recommend that a combination of approaches be employed.

The *function* of the auditor will probably not change in the future; but his *techniques* will certainly be subject to revision as a result of computer usage. One of the greatest challenges facing the systems designer and the auditor will be to devise ways of preserving an audit trail which (although it may seem to be nearly invisible) must be readily retraceable. Furthermore, this trail must be kept as simple as possible, and it must not require great masses of supporting printed detail. To perform their function properly, auditors will need to understand computer systems. A psychological barrier will be removed with understanding, and concern about an invisible audit trail will abate. As T. W. McRae writes:[8]

> *The fact that the records are not visible is a psychological rather than a practical handicap. . . .The problem is not that the records are invisible but rather that the auditor is dependent on the computer room staff for translating coded tape into a printed format.*

On the basis of the definition of internal control given earlier, we can separate the *types of controls which should be developed* into two categories.[9] In the first category are administrative controls designed (1) to promote the operating efficiency and (2) to encourage employees to comply with existing company policies and procedures. In the second category are *data or procedural controls* which are created to check and maintain the accuracy of business data. Prevention of fraud and other irregularities is controlled by organizational separation of duties and by administrative and data controls. In the remaining pages of this chapter we shall briefly survey some of the computer-related administrative and data controls which the auditor may look for during his examination.

ADMINISTRATIVE CONTROLS

In checking operational efficiency and procedural consistency, the auditor is interested in techniques which have a direct bearing on *systems design, programming, and computer operation.*

[8]T. W. McRae, *The Impact of Computers on Accounting,* John Wiley & Sons, Inc., New York, 1964, p. 165.

[9]These categories have previously been used by Professor W. Thomas Porter in several articles. See, for example, "A Control Framework for Electronic Systems," *Journal of Accountancy,* pp. 56-63, October, 1965.

SYSTEMS-DESIGN CONTROLS

We saw in Chapter 4 that systems and program *documentation* is needed to provide a means of recording, analyzing, and communicating information. Good documentation promotes operating efficiency; it also *provides the basis for the evaluation and control of new and existing computer systems.* New system specifications should be designed (and documented) with audit and control considerations in mind. (It is expensive to ignore control aspects and then have to revise and rework a designed system. The participation of a knowledgeable auditor in the design phase, so that proper controls may be built in and so that the audit trail does not vanish in fact as well as in appearance, is thus a wise precaution.) Without good supporting documents and flowcharts on existing systems, managers and auditors will probably not know if and when systems changes have been made. In short, poor documentation represents a basic internal control weakness. Therefore, one of the most important controls which can be exercised over systems design is to assign authority to one or more individuals to make sure that systems and program flowcharts, decision tables, etc., are correctly prepared and maintained. Specifically written control procedures should be established for this purpose, and, as noted in Chapter 4, standardized charting symbols and methods should be used.

PROGRAMMING CONTROLS

A detailed explanation of the purpose of each program together with copies of all related documents should be kept in a *program file.* A manual containing *standard programming procedures* should also be prepared and kept up to date.[10] The operating policies and approaches which are to be followed by personnel should be specified. Among the topics to be covered are program documentation methods and standards, program testing and modification procedures, magnetic tape labeling and retention policies, and the use of standardized symbolic names to describe company data. Such specified procedures promote consistency, reduce program maintenance problems, and make it easier for others to take over the work of a programmer who decides to leave the company.

A definite procedure should be formulated to handle *program changes.* Changes should be made only after written approval is given by someone in a position of authority, e.g., the manager of the affected department. It is sometimes a good policy to postpone making a number of minor changes until the end of an accounting cycle so that data handling remains consistent

[10] For an in-depth treatment of the topic of data-processing standards, see Dick H. Brandon, *Management Standards for Data Processing,* D. Van Nostrand Company, Inc., Princeton, N. J., 1963.

INPUT CONTROLS

The purpose of input controls is to make sure that (1) *all* authorized input transactions are identified, (2) these transactions are *accurately recorded* in a machine-usable form at the *right time*, and (3) *all* these transactions are then sent to the processing station. Among the control techniques which may be adopted are:

1 *The use of prenumbered forms.* Whenever possible, a simple and effective control is to use serially numbered forms so that documents may be accounted for. A missing number in the sequence signals a missing document.

2 *The use of control totals.* When batch processing is used, certain totals can be computed for each batch of source documents. For example, the total dollar-sales figure may be computed on a batch of sales invoices prior to, perhaps, key punching. The same calculation can be made after key punching to see if the figures compare. Control totals do not have to be expressed in dollars. They can be the totals obtained from adding figures in a data field which is included in all source documents being considered. A simple count of documents, cards, and other records is an effective control total. For example, the number of cards processed in the computer-operating department can be compared with the count of the number of cards which are delivered for processing. Similar comparisons between records read on magnetic tape and the number of input source documents may be possible. Of course, with control totals as with other data controls, the volume of transactions and the importance of the data should determine the degree of control and the amount of money which is spent to maintain that control.

3 *The use of transcription methods.* One means of controlling data transcription is to have knowledgeable clerks conduct a pre-audit of source documents prior to recording the transactions in a machine-usable form. If input is by means of punched cards, the card verifier can be used. Transaction recording devices are available which can reduce errors caused by recopying, by key punching, by illegible records, and by loss of documents.

4 *The use of programmed checks on input.* Program instructions can be written to check on the reasonableness and propriety of data as they enter the processing operation. For example, program checks can be written to determine (1) if certain specified limits are exceeded, (2) if the input is complete, and (3) if a transaction code or identification number is active and reasonable. When online processing is used, lockwords or passwords may be required from remote stations before certain files can be accessed.

PROCESSING CONTROLS

Processing controls are established (1) to determine when data are lost or not processed and (2) to check on the accuracy of arithmetic calculations. These controls may be classified into *hardware* and *software* categories. Important hardware controls include parity checks (i.e., checks that test whether the

throughout the accounting period. Changes in programs should be made by programmers and not by computer-operating personnel. All changes should be charted and explained in writing; when completed, they should be reviewed and cleared by someone other than a maintenance programmer. All documents related to the change should be made a part of the permanent program file.

COMPUTER-OPERATION CONTROLS

Computer-operation controls may be maintained in the following ways:

1 *By the use of appropriate manuals.* A standard *operating manual* should include an explanation of the procedures established to deal with such things as the issuance and return of program and data tapes and cards and the means of scheduling and keeping records of equipment operating time. A manual of *program operating instructions* should be available to tell the operator how each program should be run. These instructions can specify the peripheral equipment to use, the console-switch settings to make, the action to take on all program halts, the exceptions to standard procedures and routines which may be needed, the input data to use, and the disposition of the output information obtained.

2 *By the creation of a data-security program.* Definite controls should be established to safeguard programs and data from fire and water damage or destruction. Duplicate program and master file tapes may have to be kept at a location away from the computer site. A fireproof storage vault at the computer site is a wise precaution. The importance of proper identification of, and control over, library tapes, cards, disks, and blank forms cannot be overemphasized. Adequate insurance protection should be provided.

3 *By control over console intervention.* It is possible for the computer operator to bypass program controls. He has the ability to interrupt a program run and introduce data manually into the processor through the console keyboard. With organizational separation of program preparation and computer operation, it is unlikely that the operator will have enough knowledge of the program details to manipulate them successfully for improper purposes. But the possibility of unauthorized intervention should be reduced in a number of ways. Since, for example, the console typewriter may be used to print out a manual intervention, the paper sheets in the typewriter can be prenumbered and periodically checked. Other approaches using locked recording devices may be employed. Additional control techniques include rotating the duties of computer operators and having them account for operating time (manual intervention is slow; manipulation can thus result in processing times that are longer than necessary for affected runs).

DATA CONTROLS

Data controls are concerned with the accuracy and propriety of the data flowing through a processing system; therefore, let us consider these controls at the *input, processing,* and *output* stages.

INPUT CONTROLS

The purpose of input controls is to make sure that (1) *all* authorized input transactions are identified, (2) these transactions are *accurately recorded* in a machine-usable form at the *right time,* and (3) *all* these transactions are then sent to the processing station. Among the control techniques which may be adopted are:

1 *The use of prenumbered forms.* Whenever possible, a simple and effective control is to use serially numbered forms so that documents may be accounted for. A missing number in the sequence signals a missing document.

2 *The use of control totals.* When batch processing is used, certain totals can be computed for each batch of source documents. For example, the total dollar-sales figure may be computed on a batch of sales invoices prior to, perhaps, key punching. The same calculation can be made after key punching to see if the figures compare. Control totals do not have to be expressed in dollars. They can be the totals obtained from adding figures in a data field which is included in all source documents being considered. A simple count of documents, cards, and other records is an effective control total. For example, the number of cards processed in the computer-operating department can be compared with the count of the number of cards which are delivered for processing. Similar comparisons between records read on magnetic tape and the number of input source documents may be possible. Of course, with control totals as with other data controls, the volume of transactions and the importance of the data should determine the degree of control and the amount of money which is spent to maintain that control.

3 *The use of transcription methods.* One means of controlling data transcription is to have knowledgeable clerks conduct a pre-audit of source documents prior to recording the transactions in a machine-usable form. If input is by means of punched cards, the card verifier can be used. Transaction recording devices are available which can reduce errors caused by recopying, by key punching, by illegible records, and by loss of documents.

4 *The use of programmed checks on input.* Program instructions can be written to check on the reasonableness and propriety of data as they enter the processing operation. For example, program checks can be written to determine (1) if certain specified limits are exceeded, (2) if the input is complete, and (3) if a transaction code or identification number is active and reasonable. When online processing is used, lockwords or passwords may be required from remote stations before certain files can be accessed.

PROCESSING CONTROLS

Processing controls are established (1) to determine when data are lost or not processed and (2) to check on the accuracy of arithmetic calculations. These controls may be classified into *hardware* and *software* categories. Important hardware controls include parity checks (i.e., checks that test whether the

number of digits in an array is odd or even) and the use of dual reading and writing heads in input/output equipment. Although not a built-in hardware control, a definite program of *preventive maintenance* can pay big dividends by reducing the number of machine malfunctions.

Software or programmed controls include the input checks mentioned above. The number of possible programmed controls which may be used is limited only by the programmer's imagination.[11] Some of the possibilities include:

1 *The use of record count* As a check against a predetermined total, the computer can be instructed to count the number of records which it handles in a program run.

2 *The use of tape labels* The *external* labeling of magnetic tapes should be carefully controlled. These outside labels may give those interested such information as the tape contents, the program identification number, and the length of time the contents should be retained. *Internal* header and trailer control labels may also be recorded on the tapes themselves. The first (or *header*) record written on the tape gives the program identification number and other information. Before actual processing begins, then, a programmed comparison check may be made to make sure that the correct tape reel is being used. Since information on a master file will be erased if the file should accidentally be written upon, this is an important precaution. The last (or *trailer*) record contains a count of the number of other records on the tape.

3 *The use of sequence check* In batch processing, the records are in some kind of sequence, e.g., by employee number or by stock number. Programmed checks to detect out-of-sequence and missing cards and records prevent a file from being processed in an incorrect order.

4 *The use of structural check* A test of the transactions to be processed can be made to determine whether the debits and credits called for represent acceptable combinations. Transactions with unacceptable debit and credit combinations are rejected.

OUTPUT CONTROLS

Output controls are established as final checks on the accuracy and propriety of the processed information. Among the output control methods which may be employed are:

1 *The use of control totals* How do the control totals of processed information compare with the input control totals? For example, is there agreement between the number of records which were delivered for processing and the number of records which were actually processed? A basic output control technique is to obtain satisfactory answers to such questions.

2 *The review of interested parties* Feedback on a regular basis from input-initiating and output-using departments points out errors which slip through in spite of all precautions. Follow-up action must be taken to correct any file inaccuracies which may be revealed.

3 *The use of systematic sampling* Internal auditors can check on output by tracing randomly selected transactions from source documents through the processing system to the output destination. This should be done on a regular and systematic basis.

4 *The use of prenumbered forms* Certain output forms should be prenumbered and accounted for in the same manner as input documents. Blank payroll-check forms, for example, should be closely guarded.

DISCUSSION QUESTIONS

1 How can computer systems help managers control business operations?

2 (a) What is internal control?
(b) Why is it needed?

3 What is meant by
(a) "employee-oriented" controls?
(b) "systems-oriented" controls?

4 Of what significance is organizational structure in maintaining internal control?

5 (a) Distinguish between internal and external auditors.
(b) What is the function of the auditor?

6 (a) What is the audit trail?
(b) Why is it needed?
(c) Can it be eliminated?

7 "The audit trail will become less visible in the future." Discuss this statement.

8 Identify and describe the approaches which are used to audit computer information-processing procedures.

9 (a) What is the purpose of administrative controls?
(b) Into what three categories may administrative controls be classified?
(c) Give some examples of administrative controls.

10 (a) What is the purpose of data controls?
(b) Into what three categories may data controls be classified?
(c) Give some examples of data controls.

CHAPTER SEVEN READINGS

INTRODUCTION TO READINGS 27 THROUGH 29

27 Sheldon Dansiger's interesting article describes possible weak points in the control of computer systems which have led (or can lead) to embezzlements and frauds. Attention is then turned to ways of helping prevent fraudulent activities from occurring.

28 The purpose of this reading is to develop and explore the proposition that a systems approach is desirable in the auditing of computer-based information and control systems. The premise that sound management objectives and sound audit objectives are substantially parallel is treated in some detail. Also considered by Michael Moore are (1) the evaluation criteria and techniques which may be used to determine that an EDP system is soundly conceived and designed, and (2) the testing techniques required to provide assurance that the system is, in fact, functioning as designed.

29 This reading by Professor Gordon B. Davis presents an overview of the auditing of EDP systems. Techniques for evaluating internal control and the records produced by the systems are discussed. It is pointed out that although the auditor may or may not use the computer to carry out proper audit procedures, he should have the computer knowledge which will enable him to choose and implement the best evaluation method for each data-processing application.

READING 27 EMBEZZLING PRIMER*

SHELDON J. DANSIGER

MAGNETICALLY IMPRINTED NUMBERS

One story making the rounds in Data Processing circles is well on its way to becoming a classic. It concerns itself with the time when many banks around the country first mailed their depositors deposit slips with magnetically imprinted account numbers on the bottom.

*Reprinted from *Computers and Automation,* vol. 16, pp. 41-43, November, 1967. Reprinted by permission from Berkeley Enterprises, Inc., Newtonville, Mass. Mr. Dansiger is president of EDP Associates Inc., New York.

One enterprising young man, upon the receipt of such a set of imprinted deposit slips, promptly went to his bank and carefully dispersed his full complement of imprinted slips among the neat stocks of regular un-imprinted slips. As one would expect, these slips were used by numerous uninitiated depositors, who unsuspectingly wrote their own numbers above the imprinted ones.

The bank's processing procedure was such that imprinted slips were selected from the mass of regular checks and automatically credited to the imprinted account number. Thus it is not surprising that this same gentleman's balance totaled $67,000 the following morning. Nor should it surprise one to learn that he promptly closed out his account and proceeded on his way.

MUTUAL FUND PROCESSING

In the same vein was an experience I had while writing an IBM 7074 program for a commercial bank which processed many mutual funds. On one occasion I indicated to the processing manager, that, given five minutes alone with his mutual fund program for the ABC Mutual Fund Co. (a pseudonym), I could steal at least $10,000 from the month's run and still leave the grand totals balanced. He laughed and said he didn't believe I could do it. I created and punched the appropriate patch, which I then inserted into the program deck. We ran the mutual fund once again, and again it balanced out. He compared a number of individual accounts and they were the same; he, of course, maintained that I had failed in my attempt. At this point I told him to check account number 123456789, and as his smile faded, I knew he was convinced. The old slip had credited the account with a $70 contribution, while the new slip had given credit for a $12,545 contribution. I then took the patch out of the deck, tore it up and announced that I would explain it to the first person who bought me a good, repeat, good lunch.

The explanation was simple enough. When the number of shares purchased for a person is calculated, it goes to four decimals and is then rounded. I merely truncated and added the excess to a counter; I compared each account number to one I had built in my patch, and when I had a match I added the counter to the account and proceeded on. The account was my father's, and I am sure he would have been happy to know of his sudden good fortune, no matter how temporary it might have been.

CHESS MOVE

Finally, we have the story of the night-shift computer operator, who, having lost his fourteenth straight chess game to the computer chess program, angrily took the machine's queen with his pawn by a grossly illegal move. When, to his

amazement, the machine accepted his move (it did not check the legality of an opponent's moves), the operator smiled a tight little smile. He never lost again.

DANSIGER'S LAW OF COUNTER MEASURES

These three examples of various degrees of larceny are meant to illustrate what I have modestly entitled Dansiger's law of Counter Measures. It states:

> Whenever something is invented, someone, somewhere, immediately begins trying to figure out a method to beat the invention.

Before computers became part of the fabric of the American way of life, there were countless occurrences of embezzlements and frauds done by hand. Now, with the computer mystique ever present, the tendency is to stay away from delving too closely into the workings of the system in a company. This, I feel, lends itself strongly to a day in the not-too-distant future when a new, sophisticated style of stealing will begin coming to light. The reason for this, quite simply, is the failure of large companies to modernize their control techniques to keep up with their modern equipment.

POOR CONTROL IN BROKERAGE HOUSES

Perhaps the best example of this at the current moment is the poor controls used by many brokerage houses. In general they use what I have termed a double funnel operation, in which all the purchase and sales slips are funneled into one man, the head of the EDP operation, who then is responsible for funneling the different items out to the EDP department. A portfolio program of any sophistication could ascertain which accounts have large balances continually on hand at the brokerage house, and collusion between any one of the broker's men and the EDP man (or the operator working in the EDP department on the man's accounts) could work out many variations of the old embezzlement methods. The reason it would be more effective is simply because people have a tendency not to question a nice, neat report from a computer.

CHANGING THE TOLERANCE PERCENTAGE

Another example would be any company which carries large inventories of a diverse number of items. Traditionally, there is a difference between what appears on an inventory program calculation and what truly exists in the warehouse. Most companies establish a tolerance percentage which is meant to cover pilferage, spoilage and all other items that cause a depletion in actual amounts. A basic embezzling technique might simply require the changing of this tolerance in an upward direction, which thus would allow for a systematic stealing from the several inventories of an amount equal to the increase in tolerance.

AYROLL PROGRAMS

'he area of payroll is also a highly vulnerable one. There is an old story about a ar that did good business but was losing money. When a check was run, they oticed the bartenders rang up each sale on one of four registers. Of course, /hen it was discovered the owner had only three registers, the problem was olved.

In the same manner, computer payroll programs creating checks for employees hat do not exist, or overtime for hours not worked, represent perhaps the implest most basic examples of effective computer embezzlement techniques. 'hese can be especially effective in companies that do primarily piece work, and /hich depend on a large staff of temporary personnel with high turnover rates. \ fine example is, of course, EDP controls in an insurance company. The very mall personal contact between customers and insurance companies serves as an dditional aid to larcenous types. Collision cases which involve only the client nd the insurance company he is insured with, are prime material for this type of peration. Since there will be no contact with a second insurance company (as in ases involving a car crash with another person), the number of people needed or collusion is reduced.

IARD AND UNPLEASANT FACTS

'his article is not really meant to serve as an embezzlement primer. However, as reviously stated, the control gap is large, and specific examples of dangerous ituations that exist are probably the most effective method of getting my nessage across.

Furthermore, although embezzlement is not a nice word, the hard fact is that t exists in all fields of endeavor, and that the more liquid the cash in a company, he greater the dangers. It should be noted that all the quoted examples are ased on only a cursory inspection of various industries. Anyone with a nowledge of the intimate workings of a particular organization could develop a umber of techniques that would wreak havoc in the organization.

The question of course arises, what can be done to help prevent these ituations from occurring? It is impossible to prevent stealing in its entirety, and /hat I offer now is not a panacea, but perhaps it can be of some help.

NE SOLUTION—INTELLIGENT AUDITING

'he classical enemy of all embezzlers is the auditor who is sent in to look over a ompany's books to make sure that proper accounting systems and procedures ave been followed. In any given day a listing of all programs run should be btained, and these listings should be looked over by an outside party whose job s to determine if the programs are doing what they are supposed to be doing.

The audit should be done on a spot check basis, and the accent should be on programs that deal with cash or near cash items.

Furthermore, the embezzler works best in an area where the staff is disinterested and uninformed. One of the best defenses against stealing is an alert and informed staff. The clerks who are working on items being prepared for computer runs are really in more responsible positions than the clerks working in a manual operation. To get clerical personnel of a higher degree of intelligence and interest, you simply have to pay more money.

Both the auditor and the superior clerking personnel are items that cost money on your operation, but this expenditure should be considered an insurance expense, similar to the insurance expenses incurred regarding fire and physical theft. As a simple instance, an audit in a stock firm could take a listing of portfolios and check with the banks involved to see if the dollar holdings indicated are truly those which are being held at the bank. In the insurance company instance given previously, a good technique would be to take a given day's run on collision items and contact the customers involved to see if they really exist (or better yet, check a central credit bureau to see if they are members in good standing in the community).

To cope with the mutual fund example I provided, and with others similar to it, at irregular intervals one should take an entire mutual fund run and go thru it item by item.

OVERCOMING THE COMPUTER MYSTIQUE

Next, the computer mystique must be overcome. The following point must be driven home to the accounting department (and all other departments that may be involved): The commercial computer is not a big, black mysterious box with flashing lights. It is a tool to aid in quicker and more accurate compilation of information whose preparation is vital to a company's progress.

The basic problem here is that many executives in a firm are well versed in all facets of their business and feel comfortable in the discussion of anything relating to their business. However, they are afraid that since they do not understand the workings of the computer, they will appear foolish if they ask many questions. Probably not one man in twenty knows how his automobile works, but he knows how to deal with it, what it can do, and what he can expect from it. In a similar manner, such executives should learn how to deal with a computer, what it can do, and what they can expect from it.

DISTRIBUTING CONTROL

The final and perhaps most important counter measure is to set up your system so that not all parts of a given system are under the control of one man. Even so

simple an item as having the balance control totals prepared by a man other than the person in charge of the system would be a major safeguard.

In summation I would like to relate one final story.

In one company, a young man with embezzlement in his heart but crudeness in his techniques merely punched up cards which contained the totals he wanted to print on a summary report. He then proceeded to alter his program so that it did not process the original data, but merely printed out his totals as it read them. If the gentleman in question had not broken his leg in a skiing accident, he might still be doing it.

I rest my case.

READING 27 DISCUSSION QUESTIONS

1 "The classical enemy of all embezzlers is the auditor." Why is this true?
2 What steps can be taken to help prevent fraudulent activities from occurring?

READING 28 EDP AUDITS: A SYSTEMS APPROACH*

MICHAEL R. MOORE

The importance of the system of internal control in the approach to auditing financial statements has been recognized for years in the literature and practice of public accounting. Both the selection and the extent of application of audit procedures are determined by the auditor's evaluation, supported by appropriate tests, of the strengths and weaknesses of his client's system of internal control.

In reviewing his client's operations, the auditor has traditionally found himself able to recommend improvements in the internal control system, both to strengthen weak controls which have required extensions of his audit procedures beyond normal tests and to streamline or otherwise improve the effectiveness of the client's system. In this role, the auditor and the business manager have, or should have, a common goal: The development of an effective yet efficient system of internal control.

It is the purpose of this article to develop and explore the proposition that a systems approach is desirable in the auditing of computer-based information and control systems. This proposition rests on three basic premises:

1 There is no essential conflict between the information needs and control objectives of sound management, on the one hand, and the information needs

*Reprinted from *The Arthur Young Journal*, pp. 4-15, Winter, 1968. Reprinted by permission from Arthur Young & Company, New York. Mr. Moore is a principal in the Santa Ana office of Arthur Young & Company.

and control objectives of sound audit practice on the other. Though these needs and objectives may differ significantly—management's control objectives are generally broader and its information needs more detailed than those of the auditor—they are not incompatible.

2 Computer systems which are designed and implemented to meet management objectives will be important subjects of the auditor's tests and may also be useful to the auditor in meeting his own information needs.

3 Computer systems which are poorly designed or poorly implemented, and which do not meet the objectives of sound management, either will be of little use to the auditor or will cause him serious problems in achieving his audit objectives.

In the pages that follow, we will examine in greater detail the basic premise that sound management objectives and sound audit objectives are substantially parallel. Following that, we will consider (1) the evaluation criteria and techniques which may be used to determine that an EDP system is soundly conceived and designed and (2) the testing techniques required to provide assurance that the system is, in fact, functioning as designed.

MANAGEMENT OBJECTIVES AND AUDIT OBJECTIVES

In considering the relationship of management objectives to audit objectives, let us begin with an accepted fact: that the computer is an immensely powerful data-processing aid which is available for use by management. In each step of the management process—planning, monitoring, and controlling—the computer can play an important role. In a typical business application, for example, the functions of the EDP system might include the following:

To collect and store data in a retrievable form which will assist the managers of a business to make decisions.

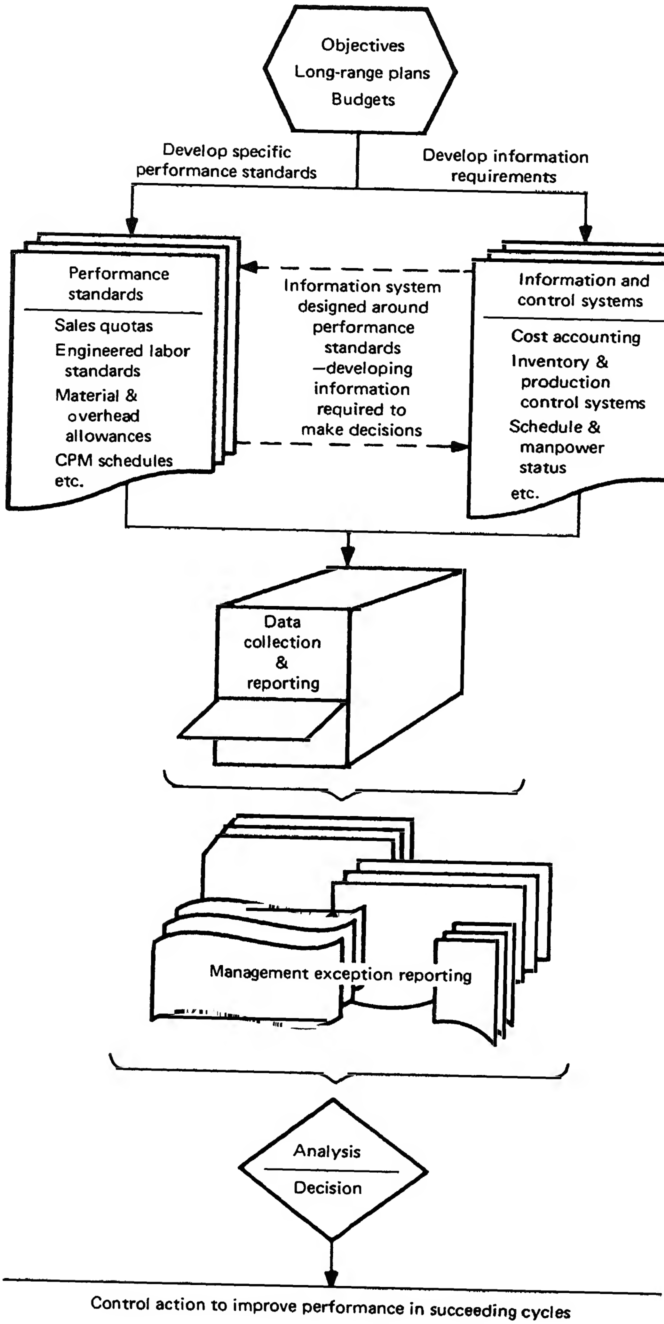
To process historical and hypothetical data which will assist in formulating operating plans, control systems, and budgets.

To select, assemble, and analyze data and to report information, summarized as required, in meaningful, action-oriented terms to management.

To initiate control actions by rejecting transactions, flagging error conditions, issuing action orders, etc.

The soundly utilized computer can greatly assist the managers of a business by providing the necessary control information and selective analyses of significant deviations from plans. As illustrated in Exhibit 1, a successful control system entails the interaction of many important elements, of which the data collection system which utilizes the computer is only one. However, the control cycle is not complete and cannot be effective without an adequate information-processing system.

EXHIBIT 1 MANAGEMENT INFORMATION AND CONTROL CYCLE



A well-conceived and successfully implemented computer installation will help management achieve its information and control objectives economically and efficiently, and as a result management will come to rely on it as a key element in the control cycle. For this reason, the auditor will want to analyze the computer system thoroughly to be assured that its controls are effective.

Although the attest function does not strictly require the auditor to consider the optimum utilization of the computer, continuous exposure to different systems approaches should equip the auditor to make constructive recommendations for improving system efficiency. Most clients logically expect their auditors to be alert to opportunities for improving the utilization of the computer and to make constructive suggestions toward that end as a by-product of their audit efforts.

The auditors interest in a sound computer system extends beyond the evaluation and testing of controls. The system also represents an invaluable storehouse of information for the auditor—in a form highly susceptible to selection and analysis for his audit purposes. Generally, management's information needs far exceed those of the auditor, and the various levels of data available in the system for management represent a valuable pool of information for the auditor, who needs only to define his needs.

A poorly conceived or poorly implemented computer installation does not assist management significantly in achieving its information and control objectives. Worse, because the control cycle depends on the data collection system as a vital link, the poorly conceived system may mislead or otherwise frustrate management in its efforts to fulfill its information and control responsibilities. There is a strong likelihood that redundant systems will spring up to provide supplementary information and control around the ineffective computer-based system.

The poor computer installation will most likely be an unimportant and ineffective link in the control system, and its usefulness to the auditor will be limited accordingly:

The auditor is no more likely than management to rely on such a system for the controls or information he needs.

The auditor selects his procedures on the basis of his evaluation of the internal control system. This is true whether the system is computer-based or manual. If there are significant weaknesses, the auditor must extend his audit procedures. He will probably extend his tests of the system; he will almost certainly extend his analysis of the resulting balance sheet and income statement accounts on the basis of the results of his tests.

The auditor is not likely to derive much value from the use of the EDP system in his audit procedures. The data files, history levels, etc. of a poorly implemented system can be expected to be inadequate, or at best poorly organized and classified, and the data-processing organization will usually be inadequate in responding to the auditor's requests.

Both management and the auditor, then, share a common objective in the design of system controls: *The extent and cost of control should be commensurate with the risk of loss in the absence of such control.* Admittedly, the application of this principle is sometimes difficult in practice, involving as it does a good deal of judgment. Nevertheless, the good business manager and the good auditor should be able to agree on the specific level of control appropriate in the circumstances.

THE SYSTEMS APPROACH

These relationships between effective computer utilization and sound internal control practices suggest the desirability of a systems approach to the auditing of EDP systems. Such an approach includes three basic elements:

Direct the audit procedures toward a "businessman's evaluation" of the effectiveness of management's use of the EDP system.

Direct the audit procedures toward assuring that the EDP system is in fact operational, organized, and effectively controlled.

Use the powerful resources of the EDP system to accomplish the audit objectives and procedures of *(a)* data selection, *(b)* comparison, *(c)* analysis, *(d)* summarization, and *(e)* reporting and other clerical functions.

Each EDP audit situation will, of course, require a different emphasis on each of these three elements. Regardless of the conditions, however, the auditor should always ask himself: (1) Is the computer system itself properly designed, organized and implemented? (2) What are the significant controls and weaknesses, and how should I test them? (3) What information is in the system, and how can I use it in my audit? Business computer applications are dynamic, and the auditor will discover different answers to these questions in each subsequent year.

The emphasis of this article is on the first two elements of the systems approach. Use of the computer in EDP auditing is such a large subject that its discussion must be reserved for another time.

EVALUATION OF INTERNAL CONTROL

The principles of sound internal control are independent of the data-processing method used. Sound organization structure, separation and definition of duties, accountability for and custody of assets, and other criteria are as applicable to the automated system as to the manual system. In any type of system, effective controls are most efficiently and economically installed if they are included in the original system design.

There are several good questionnaires available which can be used as comprehensive checklists for evaluating the internal control of an EDP-based information system. The discussion which follows is limited to the four major areas most critical in the evaluation of EDP system controls: (1) organization, (2) programming, (3) operations, and (4) hardware and software.

ORGANIZATION

Perhaps no single aspect of control is more significant to EDP operations than a strong, well-defined organization and competent personnel. This is hardly a revolutionary concept, and it would certainly seem to be one area in which there should be no conflict at all between the interests of management and the interests of the auditor. The organizational strength of the EDP group is usually the single most important limitation on the extent to which EDP is effectively applied to the information-processing needs of an enterprise. From a strong organization flow the sound system design, effective operating procedures, and control-oriented hardware and software configurations that are essential to well-managed operations.

It seems reasonable to expect that ultimately EDP operations will be centralized within an information management function reporting to a top-level executive (Exhibit 2). This organizational alignment will recognize the importance of information management to a company and the ability of the computer to integrate the capture, processing, storage, and reporting functions of a wide range of financial and non-financial information systems. Such centralization will permit the company to achieve the normal economies of larger-scale operations. While the extent of such centralization will obviously vary according to individual circumstances, it seems likely that organizational unity will be achieved even in the case of remote hardware installations. More significant than economies of scale, however, the organizational upgrading will provide the necessary authority and responsibility for the development of integrated non-redundant information systems.

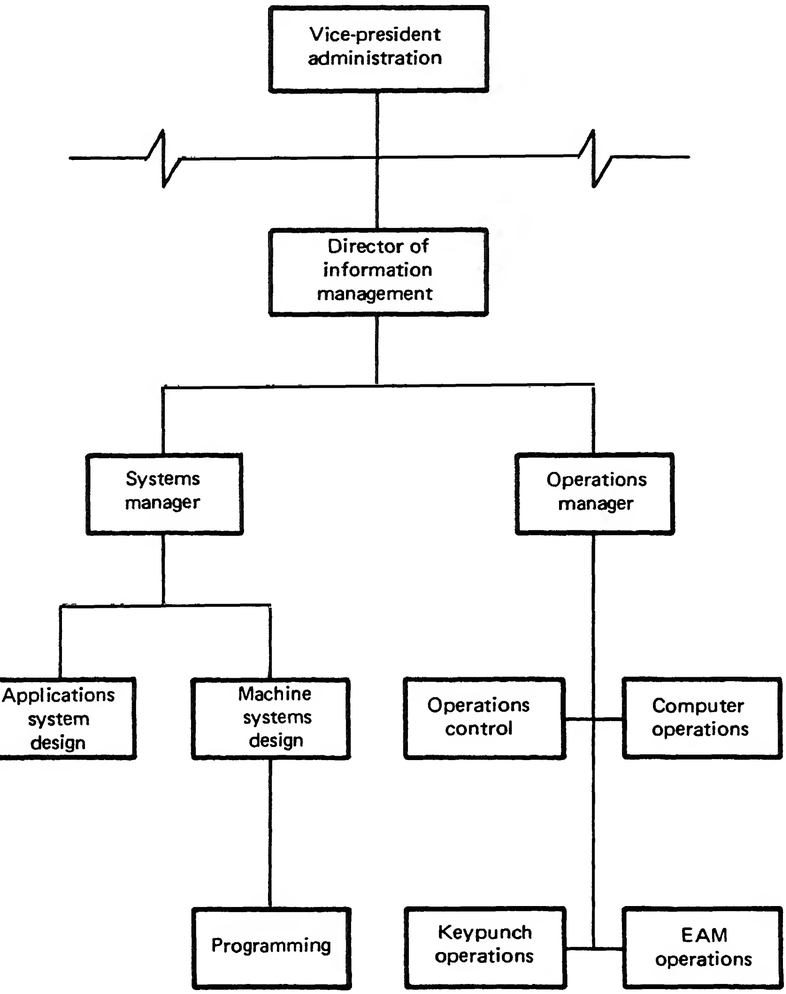
The characteristics of the information management organization should include the following, to the extent feasible:

Independence The organization should perform in a manner similar to that of an independent service bureau having the basic mission of information system design, implementation, and processing. It should not be dominated by any single user (e.g., accounting, engineering, etc.), and it should not have responsibility for the custody of company assets.

Clearly defined authority and responsibility Lines of authority and responsibility should be clearly defined, both in relation to other company functions and within the information organization itself. Written statements of authority and responsibility will help to assure the necessary independence.

Responsibility for systems design Assigning responsibility for user-oriented

XHIBIT 2 INFORMATION MANAGEMENT ORGANIZATION

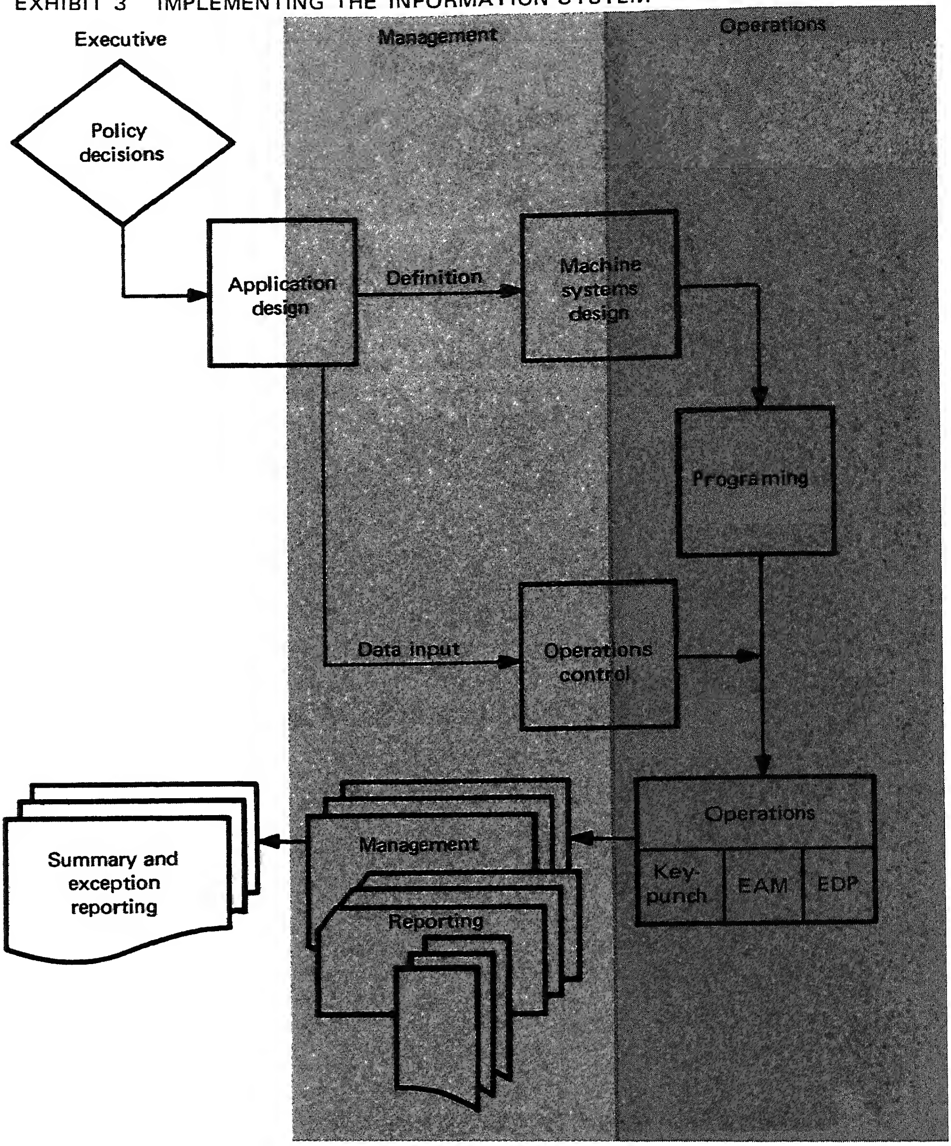


systems to the information management group will assure that adequate attention is paid to defining the form and content of information needs and the real urgency of information needs. Compromises in systems quality for programing expediency will be minimized as a result.

esponsibility for programing. The application of a computer's capabilities to a defined system need is a technical matter requiring the use of skilled specialists if the computer is to be efficiently utilized and properly controlled. A group should be separately responsible for maximizing the available computer resources and maintaining sound, consistent standards of documentation.

Implementing the information system

EXHIBIT 3 IMPLEMENTING THE INFORMATION SYSTEM



Responsibility for operations control The day-to-day operation of completed systems requires control both within the EDP organization and between that group and the user-customers. Separate responsibility should be assigned for physical control of the data files and programs and for control over the job stream between the user and the EDP operation.

Responsibility for operations Actual operation of the computer hardware should entail the scheduling, setup, and running of jobs to achieve the best possible utilization of available computer time in the light of existing schedules and deadlines. This objective suggests a highly uniform and detailed set of instructions with each job, so that the operator is required to do very little interpretation to set up and run the job.

The interrelationship of these separate elements in the implementation of an EDP system is suggested in Exhibit 3.

PROGRAMING

The second most critical area of evaluation—program controls—represents much less familiar ground to the auditor than organization and requires him to stretch himself a bit further to understand the underlying concepts. Three aspects of program control of major interest to the auditor are (1) program documentation and standards, (2) program testing procedures, and (3) program modification procedures.

PROGRAM DOCUMENTATION AND STANDARDS In a well-managed EDP operation you may expect to find a manual or some other organized statement of programing standards. Such standards assure consistency and adequacy of documentation, serve as training aids, and also constitute a useful catalogue of reusable programing approaches. Documentation of programs should be complete, following a summary-to-detail pattern somewhat as follows:

Program specification summary
General system flow charts
Supplemental narratives, and decision tables (as required)
Block diagrams of computer logic
Record descriptions: input, output, storage areas
Program listings of coding, and program decks
Detailed operating instructions

Most auditors may never learn to program or to read detailed coding, but every auditor can and should understand the principles of programing and good program documentation. The auditor can learn a great deal about a particular EDP system and can develop informed audit approaches through a review of the program documentation. To these ends, the auditor should review the program specifications, flow charts, and general narratives, and especially the content of the data files as shown in the record layouts. From these he can gain an understanding and make a preliminary evaluation of program functions and controls. Most important, he can decide which programs should be tested and what information is available, in machine-sensible form, for subsequent audit information needs.

Among the items that should be of greatest interest to the auditor are those programs or program features which perform data-editing functions. Here is an opportunity to use the very great speed, power, and consistency of the computer to build in extensive quality checks on the information being entered into and processed by the system. In effect, a continuous internal audit function is permanently installed in the data-processing system. The scope and extent of the edits to be programed are generally limited only by the imagination of the system designer and the relative cost in terms of processing time.

One of the objectives of the evaluation of internal control should be to determine that the greatest possible use is being made of the computer system's edit potential. From a management viewpoint, program edits avoid the embarrassment and cost of correcting errors, and their subsequent effects, over and over again. The auditor's interests are not different. His major concern is the avoidance of error, and the cost savings are a happy by-product. The savings-to-cost ratios of comprehensive edit programs are potentially enormous. The auditor can make a significant contribution to these edit programs simply by providing management with recommendations for additional edits on the basis of the results of his tests of transactions.

Programed edits may be grouped into two general categories: (1) housekeeping checks and (2) quality checks. Housekeeping checks include a composition check (to assure that all the data required to be in a record are there, that numeric fields are all numeric, etc.) and a code check (to verify that the codes used in the data are valid for the system and will therefore be recognized by subsequent programs). Quality checks include tests of the reasonableness of data (e.g., a check to assure that a selected dollar field does not exceed a specified limit) and tests of the interdependence of data. These latter tests can be very broad in scope and include such checks as "All payments to vendor 12345 must be charged to account 420." An analysis of the most frequently made errors will produce a number of suggestions for combination or interdependent edits.

Comprehensive edits are of great value to a batch-processing system. They are absolutely essential in a real-time environment, in which records are updated immediately upon input from remote locations and are available for information inquiry after updating. The old EDP expression "GIGO" (garbage in, garbage out) doesn't begin to describe the nightmare that can result from garbage input. Every EDP system should have garbage pails (edit programs) installed to collect the garbage being entered. The resulting system, "GIGPO" (garbage in, garbage pails out), will permit only the valid data to flow through to reports.

PROGRAM TESTING PROCEDURES Good thorough testing procedures used in developing a system are likely to be much more comprehensive than those designed by an auditor, whose information needs and control objectives are necessarily more limited than those of management. The auditor can gain considerable knowledge of a system by reviewing the existing testing procedures.

Some of the essential characteristics of thorough testing procedures are as follows:

Mock data designed to violate the edits and other controls of the system.

A large dose of "live" transaction data as an assurance check on the comprehensiveness of the mock data.

"Controlled answer" violations of the system, with proper follow-up of variations from the controlled answer.

Tests of more than one cycle of the same program to verify its updating capability.

"String tests" of the entire system to verify program compatibility from input, through processing programs, to reporting.

PROGRAM MODIFICATION PROCEDURES The most beautifully designed, comprehensively tested, elaborately controlled procedure can erode into a leaky, patchwork, inefficient, and uncontrolled procedure if adequate maintenance of programs is not assured. Maintenance control is really quite simple—at least in theory. It simply requires that the same formal documentation, testing, and approval procedures required for new applications be required to make changes in old applications.

The problem with program maintenance is enthusiasm—i.e., the lack of it. Although it is difficult to generate enthusiasm among managers and programers for restrictive maintenance procedures, the rewards are well worth the effort. Complete revision of program documentation is not necessary with each change. A notebook documentation of the change, or multi-color modifications of a basic flow chart, may be sufficient for minor changes. However, when the change, or the cumulative effect of small changes, is major, the documentation standards of a wholly new program should apply.

OPERATIONS

The third most critical area of evaluation is that of control over day-to-day operations. Close attention to the first two areas, organization and programing, will go a long way toward establishing effective controls over operations. Adequate separation of functions and the inclusion of explicit operator instructions in the programs are basic to sound operations control. It does not take a great deal of EDP experience to suggest the reasonably prudent approach to internal control over a typical EDP operation:

Good batch balancing or other controls over data at the point of origin, and continuous checking of control totals through the pre-processing stages.

Control logs covering the movement of data, including rejection and return of bad batches of data.

Some type of automatic transaction logging procedure for the real-time system having numerous remote input sources. An audit tape at the source or a

magnetic-tape log with time and input source tags on the data are examples of effective real-time input control. Comprehensive real-time edits are vital to operations control in a real-time system.

Standard uniform keypunch or other input device instructions; input forms and devices tailored to the needs and capabilities of the user and the operators.

Explicit written instructions for EAM (Electronic Accounting Machine) processing and for computer operations; an absolute minimum of operator intervention and interpretation.

Maintenance of run books, machine utilization logs, etc., and documentation of performance of jobs.

Sound labeling procedures; library control of data files and programs.

Most of the experience of both computer users and their auditors to date has been with batched-input, sequential-processing systems. The emergence of real-time random-processing systems has greatly complicated the control task even before batch-processing system controls have been adequately developed. New controls and new audit techniques will necessarily evolve as these more sophisticated systems come into increasing use. One common interim technique is transaction logging—the assignment of source input codes to each transaction. These input codes indicate, for each transaction, such data as date, time of day, source input unit, operator number, and sequence number. The codes enable the maintenance of backup records in magnetic-tape form for possible future reconstruction of input records.

Auditors have traditionally been concerned with controls over the operator at the computer console. How much of a program may be modified, or what controls may be bypassed or overridden, at the computer console? The answers to these questions will vary from one computer installation to another, because each installation is the composite of a number of control influences. Attention to the three major areas just discussed will greatly minimize the potential for bypassing organization, programing, and procedural controls. As programing techniques improve, the danger of intervention is even further minimized.

It would be extremely difficult for an operator to modify a program or to override a control in programs operating under the control of a manufacturer-supplied operating system and written in a higher-level language (such as COBOL or FORTRAN). Storage areas, input/output functions, and other elements are controlled by the operating system. The COBOL or FORTRAN compile generates multiple machine-level instructions, unknown to the operator, for each written program statement. Thus, even the most skilled operator would be hard pressed to modify the process without blowing the whole job off the computer.

Manipulation of records requires detailed knowledge of programs, adequate time at the console, and motivation. Sound internal control features such as these reduce all three of those requirements to a minimum:

- Organizational separation of functions with programs written in a non-stop mode; operators provided with detailed instructions but permitted to make few interpretations and interventions.
- Standards and effective scheduling techniques for operations—e.g., half logs, controlled console printouts.
- Separation of EDP functions from access to assets of the company and independent checks by non-EDP organizations.

HARDWARE AND SOFTWARE

Hardware and software controls represent the fourth major control area of concern to the auditor. Although these controls are vital to accurate processing, we will consider them here only briefly because they are the least likely to present control problems to the auditor. If the controls in the first three areas, discussed above, are sound, it is unlikely that hardware and software controls will be weak.

There are several good books and a number of good articles on the normal controls that can be anticipated in various manufacturers' hardware and software. If you review this literature and search your own experience and that of others, you will conclude that today's computer hardware has a generally remarkable record of reliability. The major control problems and weaknesses have not been inherent in the hardware; rather, most have been of the "nut-at-the-wheel" variety.

Hardware controls are directed primarily toward assuring accuracy in the basic computational functions. Software controls typically involve controls over the movement of data and provide checks against errors and accidental destruction. If the auditor should favor one over the other, his interest will probably be directed more toward review of the software controls.

SUMMARY

In each of these four major control areas—indeed, in all areas of control—the interests of sound business management and sound audit management are, we have seen, substantially parallel. To repeat: both the business manager and the auditor should strive to attain that level of control which properly balances the cost of control with the risk of loss in the absence of control. In the auditor's traditional role as an adviser of accounting systems, he and the business manager have a common interest: effective, controlled utilization of the computer in developing reliable and useful information.

As a footnote to this discussion of the evaluation of internal control, the auditor should consider one aspect of control which is seldom specifically included in control checklists: It can be of great potential benefit to a company to reconsider the adequacy of its insurance protection in relation to its computer operations. Typically, a tremendous concentration of investment exists in the computer installation. The investment in hardware and programs alone is

substantial, and an even greater investment may exist in the value of data files and master records on receivables and other assets. Also, the cost of business interruption is potentially increased by the concentration of records in computer files. Insurance tailored to these needs is available.

TESTS OF EDP SYSTEMS

In the systems approach to EDP audits, the computer is regarded as an asset to the control system having enormous potential. The auditor's first concern is that the computer is used to its best advantage in developing a reliable information and control system. Without testing he can walk through a computer installation, review its organization, procedures, and controls, and make a tentative evaluation of whether the installation is well organized and controlled. Under this approach, testing is limited to only the significant controls, to provide the necessary degree of assurance that the system is operating reliably. A by-product advantage of testing is that it works as a sort of mechanical self-disciplinary device to require the auditor to incorporate in his evaluation some real-life, hands-on experience with the system.

The systems approach does not minimize the importance of testing; it merely recognizes the limited purpose that testing serves. Although testing is an integral part of the evaluation process, it is simply a means of confirming previous tentative conclusions by actual sampling of the system functions and output.

The primary function of testing is to obtain tangible evidence that a program and its controls are functioning as their design indicates. Testing is the most effective means of obtaining such evidence. Another procedure which some have suggested as either a supplement or an alternative to testing is the reading of programs to evaluate their logic and to substantiate the existence of controls. This, however, does not appear to be a practical alternative to testing.

Everyone needs to know a certain amount about the technical fields and disciplines which affect his work. The effective auditor needs to know something about the underlying principles and techniques of several specialized skill areas, including statistical sampling and EDP. In my own view, most auditors will never be able, nor will they be required, to read program coding—not, at any rate, until the level of computer languages is brought a great deal closer to the user than it currently is. The existing range of programing languages and variations in their use is simply too broad for most full-time auditors to be able to master them and still maintain their skill levels in other areas of need.

Controls, then, should not be tested by reading the programs themselves. Even the programing supervisor, after all, does not spend a great deal of time reading the coding of his programers. About the only time he will do this is when he is helping a programer to debug a program. The programing supervisor is satisfied with good thorough testing procedures, and in my opinion the auditor should be too. Documentary evidence of the existence of program controls can best be

ecured by running a well-designed test deck against the program and by using ne computer to draw off sample transactions for reterence checking to original ata.

HE TEST DECK

he auditor's test deck requirements are probably not very different from those f the programers who developed test decks to check the programs when they ere first written. For this reason the use of the auditor's test deck is not likely) result in the discovery of basic system errors in a system that has been ioroughly tested upon design and has been operating under real conditions for ome time. However, the use of the auditor's test deck is likely to disclose eaknesses in the comprehensiveness of edit programs in which the data ıbmitted are valid in form but incorrect in content.

The auditor, therefore, should concentrate on developing invalid data and ontrol violations. The error input should relate directly to the specific system ontrols which are critical to his objective of being assured that he can rely on ne system as an information source. He will probably want to attempt to violate l the designed quality checks in the edit program.

A prerequisite to developing test data is an understanding of the system ontrols, the procedure for inputting data to the system, and the form in which ne results of the tests are to be reviewed. Such an understanding should be btained largely as a by-product of the auditor's walk-through of the system nterviews, flow charts, narratives) and his tentative evaluation of internal ontrol.

Test decks are essentially controlled-answer tests of a system, and as such iould employ such data as will facilitate the checking of the results. If the ffectiveness of the test is not impaired by structuring the data, it may be esirable for the test-deck data to have the following characteristics:

Special coding or names which clearly identify the data as test transactions.
Common coding which causes all the test data to appear as a group in the output.
Sequenced by type of error to facilitate checking.
Test dollar amounts that are easily recognized and reconciled.

The construction of a comprehensive test deck can be a time-consuming kercise. Experience in the technique will, however, reduce the application time n subsequent audits, in much the same way that the auditor's learning curve on ne use of statistical methods has improved with each repetition of this chnique. Although use of the test decks is a subject best approached through oecific case studies, some general observations, applicable to most tests, can be ıade.

The sample data used in the test should concentrate on violating critical ystem controls. Typical test conditions might include:

Out-of-balance batches of input.

Invalid data, such as (1) alphabetic data where numeric should be, and vice versa; (2) invalid dates, account codes, record types; (3) blank fields or extraneous data; (4) data exceeding the limits of field sizes; or (5) negative amounts where only positive amounts are valid.

Violations of all types of edits of interdependent data.

Out-of-sequence data.

Processing with wrong files.

Some valid, normal transactions also may be submitted to see how the system handles normal entries, but primary emphasis should be on violating the system controls.

In testing the on-line, real-time system, the auditor will primarily be testing the strength of the input edit controls which are so vital to a system with decentralized data input and inquiry and relatively untrained operators. Although there are a number of special problems associated with the testing of real-time systems, there is actually a real advantage to the auditor in testing such a system: in a real-time environment, the auditor has the opportunity to introduce carefully controlled test data into the system while the system is up, alive, and processing real data. What better assurance could anyone want that the program being tested is actually the program being used during the period!.

At times the auditor will have special programs written at his request to select, analyze, and report data from the client's system. These special programs also must be tested, and the auditor will want to develop test data appropriate to these programs in order to assure himself that the programs will function as he requires.

ERRORS

Not all errors have equal impact on the system. The basic system design and its tests should recognize the value of classifying errors and probable errors into three basic categories for control purposes:

Program halts—errors which are so basic to the program functions that the process should stop, be dumped off the computer, and be reviewed for the error before reprocessing. Examples of such errors are out-of-sequence conditions or a file out of balance with a system control total.

Rejection flags—errors which are sidetracked to a suspense control account and not allowed to enter the process, but which do not stop the process. The rejection flag signifies to management that the data contain invalid codes or amounts, or otherwise have a known error which is significant enough for the item to have been rejected. Examples include credit limit exceeded, invalid expense code, or a transaction to a restricted account.

Management flags—errors, probable errors, or specified conditions which are

not significant enough to be placed in a suspense account but about which management wants to be notified so that some review or other control action can be taken. Examples include items in excess of a specified dollar amount, inventory reduced below a reorder point, or a new customer in file.

The auditor can help to improve the quality of data and his ability to review the unusual transaction by having the edit programs expanded to include management (audit) flags for specific types of transactions which merit his review. This technique is a quite logical way of effecting a continuous selective review by internal audit staff without interrupting the basic computer processes.

CHANGES IN PROGRAMS

The successful handling of test data by a program will assure the auditor that the controls being tested exist in the program—and that is *all* it will do. Whether the auditor can be assured that the same program was in use during the entire period is a different and separate question. The answer to this question may be very important to the auditor, but the questions of whether controls were continuously effective or whether key persons or features of a control system may fail to act responsibly are not unique to EDP systems.

Statistical sampling techniques did not bring an element of risk to audit testing. The risk was always present—there was just no way to measure its degree. Statistical sampling techniques did, however, give the auditor an objective means of measuring risk and, in the process, improved his ability to reduce that risk through better testing techniques. Similarly, the computer system did not create the problem of requiring assurance of continuous control. It merely emphasized a problem that already existed and, in the process, gave the auditor an opportunity to gain greater assurance than ever before that controls are in effect continuously. This assurance will not be gained wholly by testing, however. The ultimate solution must lie in the development of strong organization, programing, and procedural practices which will virtually assure continuous effective control.

The preceding discussion of internal control evaluation suggested the practices which are necessary to assure effective continuous internal control. In the long run it is up to the auditor to convince his client of the necessity of implementing any of the missing requisite controls. If these controls do not exist, the auditor has no choice but to evaluate the potential risk inherent in the weaknesses and extend his audit procedures accordingly. He may, as a result, be forced into auditing around the computer.

This solution is not new to the auditor. His track record in recommending and achieving improvements in manual systems is generally quite good. When he has discovered weaknesses, he has evaluated them and extended his procedures accordingly. There is no reason to expect a basic change in this approach when the auditor encounters weaknesses in an EDP system. However, the specific

techniques of internal control and audit testing will have to respond to the new conditions.

The use of the control copy of the computer program is a good example of a control technique tailored to EDP circumstances. In a well-organized installation, a master copy of each program will be maintained separately from the copies used for day-to-day operations. As a check against unauthorized modifications to programs, this master copy should periodically be compared with the operating copies. This comparison, preferably on an unannounced basis, could be made either by EDP supervisory personnel or by the internal audit staff. Supplementing a policy of well-documented and authorized program changes, such a comparison would provide assurance to the auditor that proper procedures have been in effect throughout a period.

The audit tests themselves can be designed to reinforce this conclusion as to the continuity of controls throughout a period. For example, the auditor might make a statistical selection of input data throughout the entire period and submit the selected data as a test deck against the current copy of the program. By tracing the results of the tests to actual past system reports, the auditor can assure himself that the program tested was consistently applied during the period. As is true of all audit tests, the assurance is not 100 percent firm, but it is probably far better than that which could be achieved with a manual system.

CONCLUSION

The conclusion toward which this discussion has been leading was presented in its first few paragraphs: In examining computer-based information and control systems, the auditor must take a systems approach. Under this approach, the computer wears a white hat—it is a good guy and not an electronic crook. If the computer has temporarily gone astray, the auditor, for their mutual benefit, should bring the system back to operating in the efficient, effective way of which it is capable. Audit management and business management have parallel interests in getting the most out of given computer resources.

There are many advantages to the systems approach. The auditor who involves himself in the design considerations of computer systems has a chance to influence control systems to the greatest possible extent at a time when comprehensive controls are economical to implement. He gains a ground-floor knowledge of the system's strengths and weaknesses, as well as insights into and influence upon the procedures for error handling by the system. Finally, he places himself in a position to use the computer in his audit to improve the information on which he bases his opinion—a most important aspect of the systems approach to EDP audits which we have not touched upon in this discussion.

There is a subtle but real difference between the systems approach to auditing

and the process of auditing transactions and making systems recommendations as they occur to the auditor. As EDP systems expand in scope, more and more reliance must be placed on the system itself. If reliance cannot be so placed, the auditor will indeed be hard pressed to develop sufficient extended auditing procedures to permit the expression of an opinion. In the future, the auditor will no longer be able to compartmentalize his thinking, identifying this as an auditing matter, that as a systems matter. The systems approach will tend to become the *only* approach to an audit, and readers a few years hence will look upon the title of this article as a quaint redundancy.

READING 28 DISCUSSION QUESTIONS

1 Discuss the following statement: "The extent and cost of control should be commensurate with the risk of loss in the absence of such control."

2 What elements are included in a systems approach to the auditing of EDP systems?

3 Identify and discuss the four major areas most critical in the evaluation of EDP systems controls.

4 (a) What three aspects of program control are of major interest to the auditor?
(b) Discuss each of these topics.

5 What control techniques may be applied to day-to-day operations?

6 (a) What is the purpose of testing a program and its controls?
(b) What is the function of a test deck?

READING 29 THE AUDITOR AND THE COMPUTER*

GORDON B. DAVIS

The certified public accountant may perform many functions related to data processing—design of data processing systems, furnishing of data processing services, consultation on system design and auditing. This article is directed solely at his function as independent auditor of organizations with computer-based data processing systems.

*Reprinted from *The Journal of Accountancy,* vol. 125, pp. 44-47, March, 1968. Reprinted by permission from the American Institute of Certified Public Accountants, New York. Dr. Davis is Director of the Management Information Systems Research Center at the University of Minnesota.

THE IMPACT OF THE COMPUTER ON DATA PROCESSING

The computer is one of the most important technological developments of the twentieth century. Its uses and capabilities have been described in both popular and technical publications, so that it is not necessary to document the importance of computers in this article. The impact of computers on public accounting can be appreciated by noting the dramatic growth in numbers of computer installations for the period 1956-1967 (Figure 1). Computer installation estimates from different sources vary by about 20 percent, depending on the treatment of small computer-like equipment, but the figures show a clear trend in the use of computers. The impact of computers has been predicted for several years; the major effects have been in the last few years. Although the first commercially available computer was installed in 1951 and the first business installation was in 1954, the popular business-oriented computers can be dated from the early 1960's. Over half of the computers in place in mid-1967 had been installed in the preceding three years. The outlook was for the number of computer installations to double in the succeeding three to four years. The decreasing cost of computer equipment plus the development, now in embryonic stages, of computer-sharing arrangements clearly portend computer use by an increasing number of organizations and an involvement with computer-based records by more and more CPA firms.

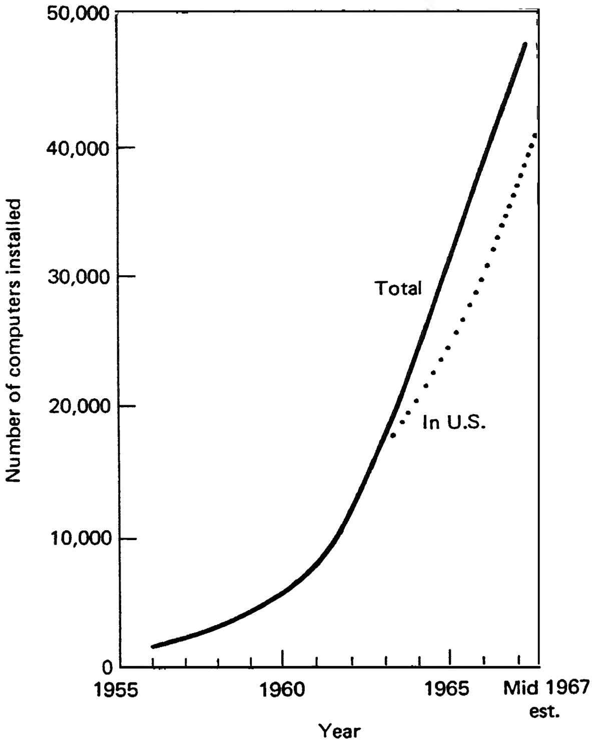
The computer has caused significant changes in business information systems, expanding both scope and operation. The first computer data processing systems tended merely to computerize existing clerical functions. Soon, however, systems embracing larger areas of the business and incorporating decision-oriented analytical techniques not practicable in clerical systems began to be implemented. Thus, although many computer data processing systems merely automate the prior manual processes, the trend is plainly toward higher level information systems. The auditor, therefore, frequently faces not only a computer but new systems concepts as well.

AN OVERVIEW OF AUDITING FOR EDP SYSTEMS

The impact that computers have had on the audit process varies among clients and is dependent to a great extent on the level of complexity of the computer data processing system. A simple system may so resemble the predecessor card or manual system that the auditor has very little difficulty in adapting his audit procedure to the computerized system. A more complex computer-based system may require considerable computer expertise on the part of the auditor for understanding the system he is evaluating and for planning his audit tests.

It is logical to suppose that auditing standards, which have been established in the light of the primary objective of auditing, are independent of the personnel or machines used to process and maintain the accounting and financial records.

FIGURE 1 NUMBER OF COMPUTERS INSTALLED BY U.S.-BASED COMPANIES FROM 1956 to 1967



The auditing standards must be broadly based in order to have applicability to a wide range of audit situations. However, they still relate specifically to each audit examination since they refer to an acceptable level of quality which must be maintained by the auditor in the selection and application of appropriate auditing procedures. Hence, auditing standards are also guides to procedures.

Auditing procedures are affected by the presence of a computer, especially when the system is complex. In describing these effects it will be useful to structure the discussion in terms of the major phases of an audit examination: (1) the evaluation of the system of internal control and (2) the evaluation of the records produced by the data processing system.

If he is to deal effectively with the computer, the auditor should have computer knowledge and capability at two levels: (1) a knowledge of computers and computer-based data processing sufficient to review adequately the internal control of the system he is auditing, to conduct proper tests of the system and to evaluate the quality of the records and (2) an ability to use the computer itself in the tests, if necessary or desirable. Whether or not the computer should

be used in performing audit tests depends on the applicability, effectiveness and cost of the alternatives for each particular situation.

EVALUATING INTERNAL CONTROL EDP does not lessen in any way the need for an evaluation of the system of internal control. On the contrary, it appears that increased emphasis must be given in the review of internal control to ascertain that it is effective. The need for this emphasis has been brought about by the centralization and the concentration of data processing in an EDP system and the appearance of new controls that must be evaluated.

The evaluation of internal control rests on a review of the system to obtain a knowledge of how it is purported to operate and on an accumulation of evidence which demonstrates how it actually does operate. The manner in which the auditor seeks the necessary information and records it in his working papers is largely a matter of individual preference. Techniques used for this purpose include questionnaires, checklists, flowcharts and narrative memorandums.

Having obtained information on the system, the auditor must next obtain evidence to determine the existence and effectiveness of the client's processing procedures and controls. This is done by making tests of the performance of specific control procedures. The nature and availability of evidence and the types of tests to be performed depend somewhat upon the complexity of the system design and upon the audit trail found in the electronic system being audited. In some cases, the evaluation of the operation of the data processing system may emphasize direct testing of the processing programs; in other cases, the evaluation may rely largely on tests using printed output from the computer processing runs.

EVALUATING RECORDS PRODUCED BY THE SYSTEM In addition to evaluating the system of data processing and control, the auditor must evaluate the reasonableness of those records produced by the system which relate to the existence and proper evaluation of assets, liabilities, equities and transactions. Historically, the records evaluated have consisted of printed reports, listings, documents and business papers—all of which were readable by the auditor. To the extent that such records are available in electronic systems, the auditor may use traditional auditing techniques. However, part of the output from EDP systems is very frequently in machine-readable forms such as cards, tapes and disks. Although output in this form can always be converted to readable printout, it presents the auditor with an opportunity to use the computer to analyze the records.

Computer audit programs can assist in the performance of auditing procedures such as: (1) selection of exceptional transactions and accounts for examination, (2) comparison of data for correctness and consistency, (3) checking of information obtained directly by the auditor with company records, (4) performance of arithmetic and clerical functions and (5) preparation of

confirmations. In using the computer to analyze machine-readable records, the auditor may either design and develop specific computer programs for each client and application or use generalized audit routines.

THE EFFECT OF THE COMPUTER ON DATA PROCESSING CONTROLS

It is incorrect, from an audit standpoint, to view the computer as a giant calculator. The installation of a computer introduces new control elements and causes changes in the form of traditional control procedures in the data processing system. These changes in controls may be classified as:

1 New controls necessary with the automation of processing.
2 Controls which substitute for those controls in manual systems that were based on human judgment and division of duties.

The auditor needs to understand the nature of these controls in order to properly evaluate and test the computer data processing system. The changes in data processing controls due to the computer are an important reason why the auditor cannot ignore the computer in his evaluation of internal control.

New controls are necessary because of mechanization. Their purpose is to detect and control errors arising from the use of EDP equipment and EDP processing methods. If these controls are absent, the system may be exposed to undue risk of error. If the omissions are considered to be serious, the scope of the audit procedures is influenced.

In a manual system, internal control relies upon such factors as human alertness, care, acceptance of responsibility and division of duties. Computer processing reduces the number of persons involved in data processing. Since the data processing activity is concentrated, many controls based on human judgment or division of duties are no longer available. However, for many checks, the computer program provides an alternative which substitutes for the judgment of humans engaged in processing. In most instances, the computer checks can be more extensive than those performed manually. The presence or absence in a computer-based system of controls such as these which substitute for human judgment or division of duties should influence the nature and extent of auditing procedures used in the circumstances.

The determination of the extent to which controls are embodied in the computer programs and the testing to determine if they are operative may utilize different techniques depending on the circumstances. One common method makes inferences about the program and the controls in it from an examination of inputs and outputs; the other method relies on a rather complete understanding and testing of the program itself.

It has been a common practice for an organization making changes in data

processing methods to seek the help of its auditing firm in designing the changes or in reviewing proposed changes for adequacy of controls. This practice has also been followed by many organizations when implementing computer applications. The pre-implementation control review is recommended because of both the probable value of an outside review of control features and the contribution of such a review to the planning of future audit procedures.

In his review of the control features in a proposed application, the auditor can point out probable weaknesses in the controls and in provisions for audit trail and safeguarding files. Making these suggestions at the time the system is being designed will help prevent undetected errors, loss of data, loss of files and other serious conditions which affect not only the client's processing but also the ability of the auditor to conduct the audit.

A NOTE ON EMPHASIS

It has been common in the recent literature of auditing to refer to two approaches to auditing computer-based systems—"auditing around the computer" and "auditing through the computer." These terms have been avoided in this article because they tend to be misleading. "Auditing around the computer" may imply to some that the auditor can ignore the computer and work around it. This is not true. The auditor should always consider the control framework in which the computer processing is carried out. In his tests of the operation of the system, he may choose to use computer printouts as the basis for audit tests rather than to test the computer program directly. For a test of the records produced by the computer system, the auditor may have the records printed out for manual review or he may make use of a computer routine to test them in their machine-readable form. In other words, he may use computer printouts in much the same way as he would use manually prepared records, or he may utilize the computer itself in performing audit steps. Consequently, this report distinguishes between auditing a computer system without using the computer and auditing a computer system using the computer.

The question of whether or not to use the computer in audit tests usually depends on the effectiveness and cost of the computer procedure versus the effectiveness and cost of the manual alternatives. This article does not favor one method over the other. The auditor should be capable of using the computer for audit tests when its use is advisable, just as he should be capable of testing without using the computer when its use is not advisable. Generally, it is not necessary or economical to use the computer to test simple data processing systems or to test files with small numbers of records. Audit tests of advanced systems or of files with large numbers of machine-readable records are more likely to require the use of the computer.

MEETING THE CHALLENGE

Perhaps the major difficulty faced by auditing firms relative to audits of computer-based records is the staffing of audits with personnel adequately trained in computer methods. Relatively few auditors have received instruction in computer methods as part of their formal training, so the profession must provide substantial training for existing personnel in order to ensure an adequate number of auditors competent to conduct audits in an EDP environment.

If an audit involves a computer, the CPA must have sufficient competence in the methods and techniques of auditing EDP systems to enable him to conduct the audit properly. The proficiency requirement implied by this statement varies depending on the complexity of the system being audited. An audit of a company having a small, batch-oriented data processing installation requires less proficiency than an audit involving a complex, integrated computer system. Not all members of the audit team need be equally competent. In general, the audit of a computer-based system requires the auditor to possess a good basic understanding of computers and computer data processing methods. A specific understanding on the part of the auditor of computer facility organization, documentation, controls, safeguards and computer system audit techniques is also important. The approach followed by many firms is to have one or more members of the staff specialize in computer audit problems.

SUMMARY

Computers have been commercially available for over 15 years, yet the recency of the major impact can be appreciated by noting that at mid-1967 over half of all computers had been installed in the preceding three years. The number is expected to double again in the next three years. Although much has been written about the impact of computers on the auditor, many CPAs are just beginning to be affected.

This article provides an overview of the auditing of an organization using a computer for record-keeping. The auditor may not properly ignore the computer in the audit—first, because the computer requires its own set of controls related to automated procedures and, second, because many controls normally resulting from division of duties and human review and judgment are now concentrated in the computer programs. The auditor may use the computer in carrying out audit procedures but this is frequently optional, depending on the characteristics of the system and the cost and effectiveness of this alternative. The auditor should be capable of choosing and implementing the best method for each data processing application and each particular audit test.

READING 29 DISCUSSION QUESTIONS

1 "Auditing procedures are affected by the presence of a computer." Discuss this statement.

2 Why must increased emphasis be given to evaluating internal control in computer-based systems?

3 How can computer audit programs assist in the performance of auditing procedures?

SUMMARY OF CHAPTER 7

Information produced by computer systems helps managers plan and control business activities in a number of ways. Of course, the information produced by computers must be of high quality if business operations are to be well managed. The purpose of internal control is to maintain an accurate and proper information output.

In manual systems, employee-oriented controls are established. Although processing efficiency is often low, the review and cross-checking of documents by several employees at separate organizational points provides a measure of internal control. When computers are used, systems-oriented controls may be substituted for some of the employee checks. Internal control need not suffer because of this substitution; in fact, it may quite possibly be improved. Separation of duties within the computer department is an organizational technique which can help maintain the integrity of systems-oriented controls.

Internal and external auditors periodically check on the adequacy of the internal control arrangements which have been made. During their examinations, auditors trace transactions through the processing systems as a means of testing the accuracy of information and the adequacy of procedures and controls. Computer usage has changed the form of this audit trail; its visibility has been reduced by the elimination of paper documents. New techniques have been developed because of audit trail changes; additional changes in audit methodology will be required in the future.

During the audit, the auditor checks to see if a proper organizational separation of duties has been made. He also wants to know if adequate administrative and data controls have been created. Several control methods are presented in Chapter 7 and in the readings that appear at the end of the chapter.

WHAT'S AHEAD IN MANAGEMENT INFORMATION SYSTEMS

In spite of the profound warning contained in an old Danish proverb ("Prediction is difficult, particularly when it pertains to the future . . ."), we shall in this final chapter attempt to summarize briefly some of the developments which may be expected in management information systems in the next five years or so. The topics to be presented are (1) *the trend toward quick-response systems,* (2) *the movement toward broader systems,* and (3) *the outlook for managers.*

TREND TOWARD QUICK-RESPONSE SYSTEMS

It should be noted at the outset that batch processing is economical, is suited to many types of applications, and will continue to account for the bulk of the processing work for some time to come. But because they allow managers to react more quickly to changes in the external environment and because they give quicker answers to inquiries, there is a trend in the direction of the judicious use of quick-response systems. Of course, the degree of quickness needed will vary; therefore, the needs of each business will determine the speed with which records are updated.

ONLINE AND REAL TIME SYSTEMS

Real time processing will become increasingly common in those applications where immediate updating of records is justifiable. When the time limitations are not so severe, online processing, with periodic updating of records, will be frequently used in place of traditional batch-processing methods. Source-document data will be keyed directly into the computer; thus, the use of intermediate cards or tapes will be eliminated, and the computer can be programmed to check input and develop control totals. The source documents which may be required will be accumulated for short periods of time, but sorting can be eliminated, batch sizes can be smaller, and data flow can be steadier.

THE GROWTH OF TIMESHARING

In the next decade there will be substantial and accelerating growth in the number of large timesharing facilities; and these facilities will represent an increasing proportion of the total computer investment. By 1970, computer manufacturers predict that 25 to 50 percent of all data processing will be performed on timeshared, multiple-access computer systems. A number of future *hardware, data transmission,* and *software* trends are intimately associated with the growth of timesharing systems.

HARDWARE TRENDS Looking first at the hardware developments which will support the growth of timesharing, we see that although the bulk of computer input in the next five years will continue to be in the form of punched cards or magnetic tape, there will be greater interest in recording data in machine-usable form at the point of origin through the increased use of online terminals. Remote input/output (I/O) consoles, transaction recorders, input tablets and light pens, display stations equipped with cathode ray tube (CRT) screens which resemble television receivers—all of these online instruments will become less expensive and will be used more often in the future. When such a man-machine interface is possible, a data-recording *medium* may not be required. The direct input techniques, then, will help to reduce the key punching of cards from source documents—a laborious translating operation.

The high-speed printer will continue to be the primary *computer output* device when information is to be used directly by man. However, there may be a trend in the direction of lessening the role of the printer. It may be bypassed by the use of online stations which will give the information requested directly to the user. Of course, if the remote station is equipped with a typewriter, a printed document will be produced; but if the station has a CRT, no printed document may be prepared. Better systems design and the utilization of the "management-by-exception" principle may also result in fewer and more concise reports. The use of voice output will grow in those specialized situations where an audio response can be given to predictable queries.

Rapid changes may be expected in the next five years in the *size, speed, cost,* and *storage capacity* of the *central processor.* The basic components will once again be greatly reduced in *size* through large-scale integrated (LSI) circuit technology. For example, Pearcey predicts:[1]

> *Sizes can soon be cut by a factor of 100 or more by intrinsic virtue of the fabrication methods for integrated electronic components. Most of a CPU may be held on a few silicon wafers of, say, one inch square. Sizes of*

[1] T. Pearcey, "The New Technologies and Their Effects on Computers and Computing," *Computer Bulletin,* vol. 10, p. 44, September, 1966.

components are reduced by up to 1,000 times and current consumption is reduced to a fraction of that currently used. . . .

This size reduction will mean shorter distances for electrical pulses to travel, and thus processor *speed* will be increased. Single users will be hard pressed to use the capabilities of the larger of these new processors in an efficient manner. Thus, greater emphasis will be placed on using them in timeshared, multiple-access systems.

Dramatic changes will also occur in the area of *costs.* In the past, there have been substantial cost reductions for given levels of computing power; this trend will continue in the future. For example, we saw in Chapter 2 that the cost to provide internal storage capacity for one binary digit had declined from $2.61 in 1950 to 20 cents in 1965; the comparable cost in 1970 is estimated to be from 5 cents to 10 cents, while the 1975 figure is predicted to be 1/2 cent! Nor is cost reduction limited to internal storage circuitry. Roger L. Sisson notes that an arithmetic-logic circuit ". . . which cost several dollars in 1955 and is now 50 cents or so will go to 3 to 5 cents [in five to ten years]."[2] A few years ago, the central processor represented 75 percent, and the input/output and peripheral equipment made up the other 25 percent, of the total value of an installation's hardware. By 1972 this relationship is expected to reverse. In fact "if present cost and performance estimates for LSI logic are realized, the hardware cost of a conventionally organized computer main frame will become insignificant relative to cost of peripherals and to software cost."[3]

Integrated circuits have also helped in the development of the *distributed-computer* concept—i.e., they have helped shift some of the processing functions previously handled by the CPU to peripheral equipment. For example, with appropriate built-in circuitry, an online station may make some of the programmed input checks described in the preceding chapter before transmitting the data to the central processor. The distributed-computer approach is likely to be developed more fully in the future.

In addition to being smaller, somewhat faster, and much less expensive, *computer storage devices* will have larger storage capability. Equipment will be available with the number of bytes of *internal* storage measured in the tens of millions.[4] Much of the equipment produced in the next five years will use

[2] Roger L. Sisson, "Planning for Computer Hardware Innovations," *Data Processing Digest,* vol. 13, p. 5, January, 1967. For predictions on computer hardware beyond 1975, see page 11 of this fine article.

[3] L. C. Hobbs, "Progress in the Computer Field," *Computer Group News, vol. 1, p. 7, July, 1967.*

[4] A "byte" is a sequence of adjacent binary digits (generally eight in number) which are operated upon as a unit.

magnetic core-storage techniques. But the trend may be in the direction of such noncore storage forms as thin film, plated wire, and sheet ferrite—all of which hold out the promise of being easier to fabricate than magnetic core planes. Research making use of laser beams and cryogenics (a branch of physics relating to the production and effects of very low temperatures) is being conducted to develop primary storage devices with improved characteristics.

External (or secondary) online storage devices will continue to be magnetic cores, drums, disks, and cards or strips. The use of replaceable cartridges gives an openended storage capability to magnetic disks and cards or strips at the present time. But in the future, the use of higher data recording densities will make it possible for each disk, strip, or card to hold more information. Online storage capacity will therefore be expanded, and direct access times will also be improved.

The future of smaller, freestanding computers is a matter of some dispute. Although these machines represent the majority of the present installations, there are some who believe that the future will see a decline in their *number* in favor of large timesharing equipment. In other words, it is felt that remote terminals connected to timesharing facilities will *replace* smaller computer installations. Some organizations will follow this route in the next five to seven years; but there will not, during this period, be a discernible trend in this direction. We saw in Chapter 2 that it was predicted that 180,000 computers would be installed in the United States and Europe by 1977. Obviously, most of these machines will *not* be large timesharing systems. However, we should keep the distinction between the *number* of machines and the *computing capability and value of each installation* clearly in mind. A majority of the computers installed in the 1970s will be "small," just as most of today's computers are small. But the number of timesharing installations will grow rapidly; each of these installations will have the computing capability of a number of smaller machines; and it has been predicted that the dollar value of the timeshared machines installed in 1970 will account for nearly half of industry sales. By 1975 about 50 percent of the total United States computing capability may be found in timeshared installations.

For the next ten years there will be an increase in the number of both large and small hardware systems. There will be increasing compatibility between smaller machines and larger timeshared ones. This compatibility will eventually (the Swami is now looking further into the future than five years) help bring about a size polarization: On the one hand, there will be large, centralized computing facilities used on a timeshared basis; and on the other hand, there will be large numbers of small and relatively inexpensive computers used independently to satisfy the particular special requirements of the user. Furthermore, many of these small, freestanding computers will be compatible with, will be connected to, and will communicate with, the larger timeshared facilities. Such communication among computers will not be limited to single organizations; rather, it will cut across company boundaries.

DATA TRANSMISSION TRENDS With increased emphasis being placed on timesharing, the trend will obviously be toward greater use of the data-communications facilities offered by telephone and telegraph companies. In 1966, vcice transmission led data transmission in the use of communications circuits by 2½ times. But by 1975 it is predicted that data-transmission circuit usage will be 20 times greater than voice usage. Between 1966 and 1975 voice usage will double; on the other hand, it is expected that data transmission usage will increase 100 times![5] Improved technology and greater usage of data-transmission facilities will combine between now and 1975 to gradually reduce the cost of data communications. Such reductions will not approach the rapid decline in computer costs expected during the same period.

Laser research and the use of communications satellites may eventually result in more economical transmission, but not in the next five years. It is quite possible, in fact, that most of the costs associated with processing a task originating at a remote station will be directly attributable to communications charges. Such charges may result in the construction of more company-owned communication systems. But most of the data-transmission facilities will continue to be furnished by telephone and telegraph companies. Teletype and voice-grade telephone channels will continue to transmit most of the data. Touch-Tone telephones, with push-button input and audio output, will become a common low-cost I/O device in the next five years. Data will be transmitted directly to a computer by "keying" the Touch-Tone buttons.

SOFTWARE TRENDS The software developments associated with the growth of timesharing which are of particular interest to managers are advances being made in the areas of conversational programming and data-management systems. When a *conversational programming* approach is used (timeshared terminals are needed), the computer itself keeps track of the acceptable vocabulary of the language and displays permissible alternate terms and statements to the user until the problem is satisfactorily formulated. The machine then computes or locates the answer to the problem. In short, the user's major skill will lie in his ability to state problems. He will be assisted by a "dialogue" with the computer as it attempts to find out what he wants to say. "Under the tutelage of the computer (for here the machine will be part teacher, part learner), the problem will be formulated until it is in a form for which a useful solution can be 'programmed' by the computer itself."[6]

Conversational programming is a feature of *data-management software.*[7] Such software, together with direct-access timesharing facilities, permits managers to

[5] See Richard G. Canning's *EDP Analyzer,* vol. 5, p. 7, October, 1967.

[6] John W. Carr, III, "Programming in the 1970s," *Data Processing,* Data Processing Management Association, Park Ridge, Ill., 1965, vol. VIII, p. 151.

[7] See Kircher's reading at the end of Chap. 2, entitled "Breakthrough in Management Information Systems" which describes data-management systems.

probe file contents in order ultimately to obtain answers to questions which initially were vague and/or poorly defined. This file-processing software "manages" the stored data items and assembles the items needed from the data base in response to the query or instruction of a manager who is not a programming specialist. To summarize, the availability of data-management systems (1) will enable managers to seek out for themselves answers to unique problems, and (2) will thereby save the time of systems analysts and programmers. There will be greater emphasis on the development and use of conversational languages and data-management software in the future.

The question of software pricing will also receive greater attention in the next few years. At this writing, equipment vendors place sale or lease prices on the hardware, but no explicit additional charges are made for the furnished software.[8] In the installation of tomorrow, however, total software costs will exceed total hardware costs.[9] Thus, present pricing policies will become unrealistic in the future. From the user's point of view, it will then be desirable for hardware and software prices to be *separated*. The best software to meet the needs of a particular user may well be prepared by the manufacturer of the selected equipment. But, with compatible equipment being produced by several vendors, it may be that another vendor's software will be preferable. Or it is possible that an independent software firm (or even another computer-using organization) will have the best software value. The user may possibly choose to acquire software from a number of sources. A separation in hardware and software pricing will enhance the growth potential of software specialty organizations.[10]

The preceding pages have identified some of the hardware, data-transmission, and software factors which are associated with the growth of timesharing systems. The majority of these systems installed in the next five years will be for the use of a single organization. But more "information utilities" will be established and will prove to be economical and successful. Beyond the five-year period, the size polarization of computing equipment mentioned earlier will begin to take shape. The speed with which information utilities appear on the scene will depend, in part, upon (1) the speed with which formidable software obstacles can be overcome, and (2) the outcome of the hearings being held by the Federal Communications Commission. At the time of this writing, an FCC investigation is under way to determine if data-transmission facilities and services

[8] An exception to this statement is found in the recent decision of Scientific Data Systems to make the COBOL compiler for their Sigma 7 computer an extra-cost option for those who need it.

[9] Frank A. Rowe, Manger of UNIVAC's Data Processing Centers Division, estimates that by 1975 only 20 percent of data-processing expenditures will be for equipment.

[10] See Carl Reynolds' article following this chapter for a discussion of the obstacles in the path of separate pricing.

are compatible with timesharing needs. In March, 1968, the Justice Department lined up behind the data-processing industry and recommended to the FCC that, among other things, the telephone and telegraph companies should remove their restrictions on the use of "foreign" devices attached to their lines and should interconnect private and public communication systems to meet the needs of the data-processing industry.[11] Final FCC decisions will, of course, have an important bearing on the future of information utilities.

MOVEMENT TOWARD BROADER SYSTEMS

In the next five years companies will increase their efforts to find ways and means of consolidating data-processing activities into broader and more integrated systems. A large number of organizations will be moving in this direction, but because of the complexities involved the movement will be gradual. Firms will increasingly seek to define and classify certain types of basic data commonly so that better integration will be possible. Developmental work on corporate data banks, which will replace a multitude of the independent files maintained at the present time, will receive greater attention. Hopefully, the issue of the potential threat to an individual's right to privacy (which has been raised by the recommendation to create a National Data Center) will also receive greater attention and will be satisfactorily resolved.

The purchase of financial and marketing information in the form of cards or magnetic tape will grow; as a result, agreement in data-coding methods between information supplier and customer will become more important and will, in some cases, lead to standardized data descriptions.

It is likely that, eventually, many data systems which cross company lines will be linked together by compatible computer networks. Buyers and sellers may integrate their systems; and firms which perform similar services (in addition to airlines) may be connected by intercompany networks.[12] In the realm of account billing and payment there may eventually be a substantial reduction in the use of currency and in the use of checks drawn on banks. The "cashless-checkless society" might operate in an individual's case as follows: (1) his pay would be credited to his account in the banking system automatically on authorization by his employer; (2) at the end of (or during) the month, the bills he owes would be entered (in the form of claims) into a banking central-clearing operation by his creditors; (3) he would approve the valid claims and authorize

[11] See Phil Hirsch, "The FCC Utility Inquiry," *Datamation*, vol. 14, pp. 32-34, April, 1968.

[12] For thoughts on these longer-range possibilities, see Felix Kaufman, "Data Systems That Cross Company Boundaries," *Harvard Business Review*, vol. 44, pp. 141-155, January-February, 1966.

the banking system to make payment (perhaps by using a Touch-Tone telephone); (4) payment would be handled automatically by the banking-system computers. One or more "money cards" would reduce the need for cash, and the need to prepare and mail checks would be largely eliminated. If all this sounds pretty farfetched to you, consider this fact: a special committee has been organized by the American Bankers Association (a sober group) to give serious thought and study to such concepts.[13] By 1977, the American Bankers Association predicts that 86 percent of the bills which the typical consumer now pays by check may be handled by electronic transfers.

THE OUTLOOK FOR MANAGERS

In the operation of their businesses, managers must contend with the rapid scientific, social, and economic movements which are taking place in this nation and in the world. Scientific advances will result in the development of new products and the appearance of new processes; and population growth will result in more people to feed, clothe, house, educate, employ, and transport. Markets will change to accommodate changing tastes, the greater mobility of the population, and the changes in age composition.

The managerial implications of such changes are clear—the manager must be prepared to make continuous readjustments in his plans. He must make decisions about new markets and about the channels of distribution to use; and he must determine how a more flexible capital investment structure can best be acquired. Furthermore, he must make these decisions within the limits of a reaction-time period which is constantly shrinking![14] If he is to compete effectively in the future, he must receive information which is accurate, timely, complete, and pertinent. Because of difficulties experienced with traditional information systems, businesses have developed quicker reacting and more integrated systems as a means of meeting their informational needs. Much more will be done along these lines in the future.

The computer is the tool which will provide needed information for managers of the future. It ". . . will help open as many new business opportunities

[13] For more particulars on the subject of the "cashless society," see John Diebold's article entitled "When Money Grows In Computers" at the end of this chapter. See also Norris F. Lee, "What's This 'Checkless Society' All About?," *Financial Executive,* vol. 35, pp. 18ff., June, 1967; and Dale L. Reistad, "The Coming Cashless Society," *Business Horizons,* pp. 23-32, Fall, 1967.

[14] President Thomas J. Ready, Jr., of Kaiser Aluminum and Chemical Corporation, has stated in this connection: "A major change now that could take place over a three-year period could occur in a year or less, five years hence." (Quoted by Jack B. Weiner in "What's Ahead in Management?," *Duns Review,* p. 32, January, 1965.)

tomorrow as past technology has occasioned today. And it will reap obsolescence in the same fashion for many businesses that are alive today."[15] If present and future managers want to prevent their firms from possibly being numbered among the obsolescent businesses,[16] they will have to prepare for a successful working relationship with computerized information processing. And they will have to learn to adapt their operations to include the use of computer-dependent decision-making techniques. The middle manager who is able to apply the coming technological and systems developments in his job should have no fear about his future. He will not become extinct; rather, he will be in demand and will function in a setting which will be more challenging and stimulating.

The computer cannot and will not make difficult managerial decisions. "But it will greatly multiply the ability, the effectiveness and the impact of those people of intelligence and judgment who take the trouble to find out what the computer is all about."[17] You now have learned some basic information-processing concepts; you have seen why knowledge of information processing is required; and you have studied some of the managerial implications of computer usage. By building upon this awareness, you will be preparing for the challenging and competitive business environment of tomorrow.

DISCUSSION QUESTIONS

1 What future hardware developments are expected to support the growth of timesharing?

2 "Rapid changes may be expected in the next five years in the size, speed, cost, and storage capacity of the central processor." Discuss this statement.

3 What is meant by the distributed-computer concept?

4 (a) What is conversational programming?
  (b) What is data-management software?
  (c) Why are these software concepts of interest to managers?
  (d) How do these concepts relate to timesharing?

5 Why may it be desirable, from the user's point of view, to have separate prices for hardware and software?

6 What is the proposed National Data Center?

7 What is meant by the "cashless-checkless society"?

[15] James H. Binger, "The Computer: Engine of the Eighties," *Advanced Management Journal,* p. 27, January 1967. This article appears at the end of this chapter.

[16] For a further discussion of industry, organizational, and managerial obsolescence, see Head's article at the end of this chapter.

[17] Peter F. Drucker, "What the Computer Will Be Telling You," *Nation's Business,* vol. 54, p. 90, August, 1966. This article appears at the end of Chap. 3.

CHAPTER EIGHT READINGS

INTRODUCTION TO READINGS 30 THROUGH 33

30 Carl Reynolds considers in this reading the questions of whether software should be sold separately from hardware and whether it should be protected from unauthorized use. Some obstacles in the path of separate software pricing are mentioned.

31 Four questions are considered here by John Diebold. These questions are: (1) What is the cashless society? (2) How will the cashless society operate? (3) Why is the cashless society needed? and (4) What enterprises will operate parts of the cashless society system?

32 In this reading, Robert V. Head considers the computer's role in the obsolescence of business organization and management under the categories of (1) obsolescence at the industry level, (2) obsolescence within a business organization, and (3) obsolescence as it affects the administrative and professional skills needed for business management.

33 This article delves into some of the broader social changes which may appear in the 1980s as a result of computer usage. James Binger writes that in addition to being concerned with man's productive capacity and with the sustenance of life, we must also become concerned today with higher levels of human needs. It is in filling these needs that computers will play their most vital roles.

READING 30 SOFTWARE PROTECTION AND SOFTWARE SALE*

CARL H. REYNOLDS

Recent events have revived the questions of whether or not software should be sold separately from hardware and whether it should be protected from unauthorized use. Scientific Data Systems has announced that the COBOL compiler offered with its Sigma 7 computer would be an extra-cost option "for those who want it."

*Reprinted from *Data Processing Magazine,* vol. 9, pp. 50-51, May, 1967. Reprinted by permission from North American Publishing Co., Philadelphia, Pa. Mr. Reynolds is president of Computer Usage Development Corporation.

On the protection side, the U. S. Patent Office recently held hearings on guidelines for patenting of programs. About two years ago, the first copyrights for computer programs were issued, at a time when the Patent Office deemed programs to be not patentable.

Both questions are interesting in view of the huge sums of money being spent to produce programs. Current estimates of annual expenditures vary from $1 to $3 billion, and expenditures are expected to grow many times that figure by 1970. Expenditures of this size make the prospects of earning added return on them worthy of consideration . . . presently there is no business endeavor of comparable size with noncapitalizable products. The two questions are obviously related because many manufacturers feel that software can be sold separately only if there is protection against unauthorized copying and use.

"Protectionists" are opposed by those who say it is not in the public interest to restrict the free interchange of programs if full benefits are to be derived from the fantastic growth in the use of computers. Representative Jack Brooks of Texas made this point in reference to the patent office hearings in his talk before the Fall Joint Computer Conference. Chaos might indeed result if the first person who wrote down a sequence of instructions for a computer could patent the program embodying that sequence. Yet, strangely, if a sequence of instructions is translated into a hardware system, the resulting machine feature is patentable under current regulations. In fact, several examples of such patents are pending right now.

PATENTING VS. COPYRIGHTING

Although patenting of programs seems to threaten a sort of stranglehold on the industry, operationally it is too slow to be effective. It now takes approximately five years to get a patent and few programs have five-year lives. Copyrighting of programs is certainly faster but may be less effective without some definition of "plagiarism" or unauthorized copying as it applies to programs.

There is no question that a program which can cost as much as a quarter of a million dollars to produce, but perhaps $50 or less to copy, will attract infringers and piraters. However, both patents and copyrights must be policed if they are to provide effective protection. Perhaps, better protection will result from a machine or programs feature (to be invented), that permits protected programs to operate only when, or as often as, the program owners say they can be.

Software sale has some interesting ramifications of its own. It has always seemed to me that most software production difficulties and much user dissatisfaction arises because users have little choice among, and virtually no basis for judgment of, the products offered them by the manufacturers, software houses, or their own programmers. Some economic trade-off is available in

almost every other industrial purchase: price versus quality, price versus function, price versus performance. Not so in programming. We do not know very well how to measure quality, function, or performance and usually we have only one source.

The lack of an economic evaluation hurts the programmer, too. His job is never finished because the standards for evaluating his product change drastically from initial design to final operation. First, he must achieve function, cost, and schedule. Then the emphasis shifts to "unimportant" functional problems, machine configuration, and, finally, performance.

NO EXTENDED RETURN

From the software houses' viewpoint, an outstanding programming job rarely yields any extended return (other than in enhanced reputation) commensurate with its quality. In most other fields of endeavor, the rewards for doing something very well are continuous. For example, a good movie generates profits as long as somebody wants to see it. When a software firm or any programmer completes an outstanding job, it or he just goes on to work hard on a new project.

What does all this have to do with the SDS announcement of its Sigma 7 COBOL compiler with a price tag on it? SDS explained that not all customers needed COBOL and, therefore, not all customers should pay for it. I would be curious to know what the COBOL users are saying about getting FORTRAN free. However, first steps are worth something.

The success of SDS's strategy depends upon how many COBOL compilers they sell. As a guess, the compiler will cost between $100,000 and $200,000 to produce. At a sale price of $25,000, they must sell from five to 10 copies to cover costs and start showing a profit. Whether or not SDS can sell that many depends in turn on the cost of the Sigma 7 plus the cost of the COBOL compiler being competitive with machines for which the COBOL compiler is supplied "free of charge."

I believe that, in the long run, a good deal of the software now "given away" with hardware will be charged for on a regular basis. When this happens, the user will be in a position to choose the compiler that best suits his needs.

This rosy future is clouded, however, by many problems. The need for software protection is one. Another is the problem of maintaining purchased software. Still another is the unresolved question: will "sold" or "free" software better allow continued growth of the computing field? Software now, whether "free' or "sold," offers functions, abilities, and performance that were unimagined just a few years ago. Yet the business aspect of software production creeps along with only a little more sophistication than when we started.

READING 30 DISCUSSION QUESTIONS

1 (a) How may computer programs be protected from unauthorized use?
  (b) Why is the question of program protection relevant to the sale of software?
2 Discuss the pros and cons of the need for program protection.
3 What obstacles lie in the path of separate software pricing?

READING 31 WHEN MONEY GROWS IN COMPUTERS*

JOHN DIEBOLD

About 2,000 years ago a man called Publilius Syrus said that "money alone sets all the world in motion." This may be true. But what keeps the world going and determines its speed is how the money itself moves. When money moved slowly and erratically, the world moved slowly and by fits and starts.

Most knowledgeable people seem fairly sure that money will have to move ever faster to meet the needs of tomorrow. And many are even resigned to calling the terminus of this movement "the cashless society," although, as we shall see, this state is unrealizable—at least so far as the immediate future is concerned. But there is considerable vagueness on all four key questions bearing on the subject:

The *what* of the cashless society—the contours of the system.
The *how* of the cashless society—the technology needed to realize it.
The *why* of the cashless society—what the country and business stand to gain from it.
And, perhaps most intriguing, the *who* of the cashless society—what enterprises will operate parts of the future system and what changes in the traditional functions of these enterprises the system will induce.

The article will consider these four questions.

First, what is the cashless society? For one thing it won't be cashless: the term is a misnomer; a substantial number of transactions will continue to be made as they are made today, using currency, checks, and other traditional means. Actually, the outstanding characteristics of a future system of electronic credit and money transfer will be a great reduction in paper handling of all kinds and a resulting decrease in transaction times, errors and costs. To characterize the future system as "cashless" is about as accurate and meaningful as characterizing our present system as "barterless." But we are more or less stuck with the term.

*Reprinted from the *Columbia Journal of World Business.* vol. 2, no. 6, pp. 39-46, November-December, 1967. Reprinted by permission of the Graduate School of Business, Columbia University, New York. Mr. Diebold specializes in the management impact of advanced computer technologies. He is president and chairman of The Diebold Group, Inc.

For consumers the cashless society will mean the carrying of one or two cards with which to make cash payments or obtain credit at the time and place of purchase, or from any other location, over the telephone. One card could serve both the cash and credit transfer functions, or there could be two cards—one for cash and the other for credit. In order to prevent fraud, various types of identification procedures will be available, including photographs on the cards, signature comparison, and voice identification. Consumers will be able to transfer cash from their own to others' accounts, or they could ask for credit through the system. Both the cash transfer and the amounts and terms of credit received will depend on the cash in the consumers' accounts and on their credit ratings, as recorded within the system. In addition, for a number of purchases, transactions similar to current credit-card usage will take place. That is, at the discretion of the retailer, accounts receivable records will be established in the system and the consumers will be billed from that account at regular intervals. It is possible that consumers eligible for this type of transaction will have some kind of designation on their cards, indicating a general, good credit rating, just as today such a rating is implicit in the possession of a retail or travel and entertainment credit card.

Automated interbusiness transactions will form the other part of a future system. This will be simply an extension of current accounting procedures which already are being increasingly handled by computers. It is likely that certain service companies, such as computer manufacturing subsidiaries, accounting firms, communications companies, banks or others will provide the means by which payments and credit arrangements will be automatically made and recorded without the use of papers for billing, payment and confirmation which is currently required. Business accounts in banks will be debited and credited on a regular and predictable basis.

Three matters of importance in the functioning of a future system of electronic credit and money transfer for consumers and among business should be pointed out specifically.

One, delays in payment will be built into the system, as individual cases require. For example, the buyer of a television set could delay payment to the retailer until delivery and inspection of the purchase. In this case, the consumer's account would have a record of a pending obligation and the retailer's, a record of a pending receivable. The actual transfer of the money would be delayed according to the terms of the purchase. In other words, neither individual consumers nor businesses will fall into the clutches of a relentless, inhuman system automatically disposing of their money regardless of human error and the individual's right to change his mind.

Of even broader and greater significance to an individualistically oriented society is that current projections are based on the assumption that up to one-third of all transactions within the United States will not take place on an automated, cashless basis. Individual preferences, legal requirements and cost

factors will always preserve the use of checks, currency and even barter as acceptable means of exchange. Undoubtedly the use of these means will continue to shrink, both in relative and absolute terms, as the electronic system becomes more flexible and sophisticated. But just as today we have forms of barter in hard goods (automobile trade-ins, for example) and in corporate acquisitions, the future will also leave room for older forms of transactions.

Finally there is the matter of privacy. Fear has been expressed that the availability of individuals' total financial records, concentrated in one or two computer memories, will present dangerous opportunities for the invasion of fundamental rights. There are at least two safeguards against this danger.

In the first place, the operators of an automated system are likely to be competing with each other. The competitive nature of the electronic credit and money transfer business should offer substantial protection against the exploitation of private information by the business operating the system. It is probable, however, that strict legislation will be needed to prevent governmental interference at all levels, similar to the current wire-tapping problem.

In the second place, the very technology of the system should offer protection against random or criminal misuse of private information. The various pieces of information on individuals will be stored in a manner which will make them available only in the form of answers to a very specific and limited set of questions. The retrieval of other types of information will involve basic searches through the electronic files at relatively high costs. Legislation probably should be enacted to make such searches allowable only at the discretion of the individual to whom this information pertains. Thus, the technology protects the individual against the misuse of specific bits of information more effectively than do the mainly uncoded and written documents in today's filing systems.

From the question "what," we turn to the matter of "how"—the nature of the technology that will operate the cashless society. Most of the technology required for the operation of a fully automated credit and money transfer system in the United States is available today. Very broadly, the technologies needed in a future system can be placed into the following categories.

TERMINAL EQUIPMENT This will consist of devices placed in banks, homes, and retail and service establishments to permit communication with the central processors and files. The terminals will be of the modular, building-block type which can be assembled to meet the different requirements of specific locations. They may include a touch-tone type input, a card reader and an audio-response unit, as well as several lights indicating system conditions and replies. Thus the terminals would be little more than variations, with accessories, of the touch-tone telephones which are already being installed by the Bell Telephone System and are expected to be in widespread use by the end of the 1970s. Credit card and similar types of information could be entered via the pushbuttons or with a device similar to the automatic card dialer already available from Bell.

This relatively simple and inexpensive type of terminal system could be integrated with more complex information (data utility) terminals in business establishments. The terminal devices will add relatively little to the basic costs of future telephone and data utility services for those utilizing one or both of these services in the first place.

COMMUNICATIONS These may well be provided through a type of Wide Area Telephone Service (WATS). This is a service which permits a customer, by use of an access line, to make calls within a specified zone for a flat monthly charge. It is now being offered on an "outward" basis nationally and is experimentally available on an "inward" basis in several states. "Inward" WATS appears to be most suitable for communications in an automated credit and money transfer system. The communications element, as a whole, may account for up to 50% of total system costs, depending, in part, on Federal and state regulatory policy decisions, and in part on expected improvements in existing technology and operating procedures utilized by United States common carriers.

CENTRAL PROCESSING UNITS AND MASS STORAGE FILES The computing power of currently available third generation central processors, and the capacities of currently available random-access or disk-type memories are fully adequate to the demands of a future system. For example, the Burrough's 5500, RCA Spectra 70/55, IBM System 360/50, or CDC 3600 computers, ranging in average cost from $1.1 million to $2.3 million each, could serve consumer transactions in any specific region or metropolitan area. Also on a regional basis, computers such as the Digital Equipment Corporation's PDP-6, the CDC 3300, and the Scientific Data Systems Sigma 7, ranging in average cost from $600,000 to $800,000 each, could serve interbusiness transactions.

PROGRAMMING AND SYSTEMS ANALYSIS, DESIGN AND INSTALLATION These techniques, as developed today, are perfectly adequate to the needs of an automated credit and money transfer system. However, they are costly and subject to great variations depending on the skills of the personnel involved and the diversity and sophistication of the system required. This last element—the variables of system complexity—could well be attributed, at least partly, to marketing costs. The specific services provided, including various safety factors and amounts of information made available to users, will depend to a large extent on user demands, as well as on regulatory and insurance requirements.

The one technology which is not available in commercially marketable form at this time is represented by voice recognition units. These probably are fundamental to the security of procedures which electronically debit and credit cash accounts, as well as to the privacy and safety of individuals desiring to make medium-sized and larger purchases on credit. It is expected that voice

recognition units will be commercially available by 1971. They will consist of devices which generate voice spectrograms as the result of voice inputs. These spectrograms will then be converted to digital formats for comparison with the digitalized voice patterns in the identification files of individuals. The technology and the communications time needed for this type of identification procedure are projected to account for a substantial part of the total system-operating costs.

TRANSACTIONS EXPLOSION . . .

So much for the technology of the system. Now, after considering the "what" and the "how" of the cashless society, we ask ourselves: "why" do we need it? The answer isn't hard to find. It is generally accepted that U. S. economic activity must at least double during the next 15 years if it is to meet the demands of a growing population for greater quantities of higher-quality goods and services. According to detailed projections developed by my firm, the number of financial transactions, and the volume of data exchanged and recorded in connection with them, will have to increase two to five times over current levels—depending on the specific type of operation—in order to support the required expansion of economic activity. These projections are based on a correlation of past trends and the application of certain of these trends to some of the most promising business innovations in such areas as credit facilities, leasing arrangements and checking-account operations.

Examples of the projected two- to fivefold increases in the number of financial and data exchange transactions are:

A more than twofold increase in the amount of longer term (more than 30 days) consumer credit outstanding, from $95 billion to $220 billion.

A nearly threefold increase in consumer credit repayment transactions, from 2.2 billion to 6 billion annually.

A fivefold increase in the number of consumer credit operations, i.e., individual applications for short, revolving, and longer-term credit, from 300 million to 1.5 billion annually.

A two- to threefold increase in transactions now involving the writing, drawing and depositing of checks by individual consumers and by business enterprises, from 17 billion to 40 or 45 billion annually.

The current costs of these credit and money transactions, at 1967 levels, for banks, other financial institutions, and business enterprises are estimated by our researchers to total some $13 billion annually. No estimates are attempted on costs to consumers, in terms of time spent and losses. This $13-billion figure includes operating expenses, as well as losses resulting from fraud or error. About $6 billion derive directly from credit transactions, and about $7 billion

from check transfers. Looked at from another angle, about $7 billion of these costs are borne by banks and other financial institutions, and $6 billion by the rest of the business community.

. . . LEADING TO OVERLOAD THREAT

Current annual costs of financial transactions would increase to some $35 billion annually if the present system were to expand sufficiently to support a twofold increase in national economic activity. But even if such costs could be borne, it is highly unlikely that they will be, if any alternative is available. To project a doubling of gross national product by 1982 on the basis of current means of financial transactions is similar to expecting the 1967 volume of telephone calls to be made through the 1952 telephone system, with its reliance on operators, limited local dialing, no long-distance dialing, mechanical switching, etc.

TOTING UP THE SAVINGS

On the basis of the projected volumes of financial and data transactions and the technological costs of an automated system, rough estimates of cost savings and other business opportunities accruing from the cashless society can be drawn. We have said that up to one-third of total United States transactions around 1982 will take place in a manner similar to today, while some two-thirds will be automated in a system along lines described above. Thus it will cost $12 billion, more or less (one-third of $35 billion) for transactions which will continue to be consummated outside of an automated system. But what figure do we add for the system itself?

Most of the hardware costs of a future system will be reduced by more than one half during the next 10 to 15 years. Programming and related costs will also be reduced, though not by as much. Marketing and managerial costs are very difficult to estimate but can be safely assumed on the basis of past experience to equal hardware and software costs, at least over the first few years, if capital investment expenditures are prorated over this period.

All in all, it is projected that a national system of electronic credit and money transfer will cost about $4 billion annually over the first five years of wide-spread implementation. Basically it has little effect on operating costs whether one-third or two-thirds of all transactions, regionally or nationally, are made through the system. In either event, the equipment and other facilities will have to be there and will have to be paid for. Thus the intensity of actual implementation is of relatively little interest to a discussion of technological cost factors.

The figure of $16 billion ($12 billion for conventional transactions and $4

billion for the "system") annually represents a reasonable increase of less than 25% in the total costs of handling transactions which will have increased two- to fivefold in volume. The business opportunities for the operators and users of a future system and the benefits to the consuming public reside, in part, in the difference between the theoretical $35 billion cost of doing things as they are being done now, and the projected $16 billion cost of doing them through the application of advanced computer and communications technologies. In part, also, these opportunities and benefits reside in the totally new services and conveniences which an automated system will provide. And, more broadly, the interest in such a system, both for operators and users, resides in the probability that the purely physical problem of handling the increased volumes of transactions by current means would prevent a substantial part of these transactions from being made at all. In other words, an automated system not only will provide cost savings and new opportunities but will make possible the volume of transactions from which these benefits derive.

WHO WILL DO WHAT?

Since it is not easy to make specific predictions on the extent to which various enterprises will actually operate parts or all of a future system, it is difficult to project the distribution of savings, profits and other benefits. Much depends on the planning abilities and the negotiating strengths of the various interests involved. However, it is possible to identify the types of enterprises which will be involved in the competitive struggle for the markets provided by a future system, and to do so in the context of the problems facing them. This takes us into our last question, the "who" of the cashless society.

Since our economy is consumer-oriented, a large measure of the problems facing most of the potential operators of an automated system is in the marketing sector. The consumers and other potential system users must be sold on the conveniences, financial benefits and increased safety and personal privacy which such a system offers. Three types of benefit come to mind:

1 Consumers—in this instance including business enterprises using the system—will have available to them, at the push of a telephone touch-tone knob, a complete picture of their latest financial position: Obligations, assets, predicted income and outgo. They will have this without having to balance checkbooks, calculate real interest rates or project predictable future expenditures.

2 For a fee, financial services provided through the system will advise customers regarding their optimal payment and investment schedules, eliminating the need to juggle payments against income.

3 Accounts and records kept in computer memories will protect consumers and others against accidental and, in most cases, against premeditated disclosure of their financial positions to unauthorized eyes.

These, then, are the things which the operators of an automated system have to sell. The marketing of these benefits is one of their major challenges. The way they meet this challenge will determine to a large extent how the technologies available are applied and who will own and operate these applications. In this context one can identify the groups which will be involved and, to a limited degree, the nature of their involvement.

COMMERCIAL BANKS Two propositions are of interest here: (1) Although a large majority of bankers expect the cashless society to come about soon, a small but important minority disagree; and (2) among those who expect it to arrive presently, few can agree on how the cashless society will develop or how to plan for it.

The first of these conclusions is borne out by the survey, *The Impact of Electronics on Money and Credit,* undertaken last year by The Diebold Research Program. As part of a continuing study of the managerial implications of technological change, a 29-question survey was sent to some 10,000 individuals, including more than 4,000 presidents and other top executives in banking. Twenty-seven percent of the respondents do not believe that a "cashless society" will develop within the next 10 to 15 years. Even among the 100 leading banks, this view is held by 20%.

The second conclusion finds support not only in the survey but in the apparently chaotic reactions of a large number of bankers in the credit-card and related areas of credit and money transfer. Some 95% of the bank respondents to the survey, expecting a cashless system of credit and money transfer, believe that banks will play a major role in such a system. But there is wide disagreement among them as to how it will come about—through the further development of credit cards, the expansion of automatic overdraft privileges, the automation of interbusiness transactions, or other means—and as to who, if anyone, will be the operating partners or other principal beneficiaries of an electronic system. Close to 1,000 United States banks are now reportedly in the credit-card field, many with highly mixed results in terms of profits and doubtful prospects for long-term viability. A large number of others are instituting automatic overdraft privileges and/or check-cashing guarantees, largely as an alternative to—not an integral part of—credit-card operations. At least one of the very major banks is looking once again at the possibility of entering the travelers-check market—a business with a glorious past and a rather uncertain domestic future.

However, in spite of the generally disorganized response of the banking community at this time, it is difficult to believe that commercial banks will not play a major part in both the ownership and operation of an automated system. Any other possibility would imply their abdication of the central role in our nation's financial affairs which they have sought and played with increasing aggressiveness. The real questions are: How many mistakes will the banks make

n the way and how much will those mistakes cost them, in terms of money and ffective control of a future system?

THER FINANCIAL INSTITUTIONS These range from savings and loan anks and investment houses to credit-card companies. These institutions also ave an important role in our current system. However, in some cases it is a eripheral role, while in others, such as with the more important credit-card ompanies, it reaches into the very heart of the consumer and retailer markets or an electronic system. The future role of these institutions depends, much nore than in the case of commercial banks, on the success of their immediate lans to obtain relatively invulnerable market positions, regionally or nationally. they succeed in this, it will be difficult for others to edge or buy them out of gnificant ownership and operational roles. If they do not succeed, they will be bsorbed by the future operators, or even cast aside.

IAJOR RETAILERS Although major retail establishments do have a consider- ble interest in consumer-credit operations, this is primarily in support of their nerchandising business. It is quite possible that they will seek an ownership—nd, in some cases, an operational—role in a future system, in order to protect ne customer relationships which they help to maintain through their credit ctivities. It seems more likely, however, that in most instances major retailers ill find it more profitable to safeguard their interests through their weight as sers or customers of the services which a future system will offer. Nevertheless, nis may well vary among regions or cities, depending on the capabilities of anks and others, as well as on managerial decisions among the retailers.

OMPUTER AND OTHER MANUFACTURERS There is a distinct possibility nat such companies—especially those in the computer field—may wish to enter nto the operations of credit and money transfer. This would involve some major iversification moves, which could be justified in terms of a defensive strategy or s extensions of internally effective computer-communications operations. The ariables in this possibility are so great that it would be futile at this time to ndicate more than just the potential interest and capabilities of such nanufacturing companies.

OMMUNICATIONS COMPANIES The very nature of a future system points ɔ the importance of communications. However, whether communications ompanies will merely service or actually own and operate parts of such a system epends again on the effectiveness and plans of banks and others. Another nportant variable in this case concerns governmental regulatory decisions egarding common carriers.

It should be clear from the foregoing discussion that the other major nallenge—next to technological application and marketing—facing future

operators and owners of an automated system resides in the potential obsolescence of the products and services they currently offer. In order to make up for the effect of this on sales and profits, they will have to evolve new markets. A number of examples come readily to mind.

Computer manufacturers probably will sell fewer machines to individual banks and businesses within a future system. They will have to sell hardware and services to the system itself. Retailers may have to extend credit *through* the system instead of individually. Credit-card companies will find their services either are being absorbed by a future system or are becoming an important part of it. Commerical banks will see the *need for* and *profits from* demand deposits shrink, as automated credit and money transfers allow businesses and individuals to operate with relatively smaller liquid balances. They will have to seek sources of revenue from the operations of the system itself and through new services, such as the highly sophisticated management of individual and business accounts.

Thus, not only will the means of financial transactions change, but the very nature of many businesses will be substantially different. We will be in a time when money grows in computers, and those who wish to obtain their portion will have to learn new ways of reaping this harvest.

To sum up: we have said that the future demands that the world move quickly and safely, and that this means that some system must and will develop in which money (and credit) moves quickly and safely. A probable future course of events toward this end in the United States is outlined in this article. In other parts of the world—Western Europe for example—the timing and the shape of events are likely to be somewhat different. But this is in itself a subject for a detailed discussion, including an analysis of the relation of these areas to the financial and business communities of the United States.

Of course, events take on quite unexpected shapes. And this, perhaps, would really be the least startling thing about the so-called cashless society. Nothing is easier or safer to predict than the unpredictability of events moved by men. And, although money may set the world in motion, men move money.

READING 31 DISCUSSION QUESTIONS

1 (a) What is the cashless society?
(**b**) What does it mean for consumers?
(**c**) For businesses?

2 (a) How will the cashless society operate?
(**b**) What technology is required?

3 (a) Why is the cashless society needed?
(**b**) What are its possible benefits?

4 (a) What enterprises will operate parts of the cashless society system?
(**b**) How will their traditional functions change?

DING 32 OBSOLESCENCE IN BUSINESS ANIZATION AND MANAGEMENT*

ERT V. HEAD

nsidering the role of the computer as an agent of obsolescence, it is difficult ne contemporary observer to comment perceptively. The problem is akin to of the historian seeking to analyze events of the present. In many instances nay be on the road to obsolescence without really knowing it, still viewing omputer as a complicated and rather fractious curiosity much as the horse buggy driver regarded the automobile. What, in historical perspective, turns to be profound change may be achieved almost stealthily and escape nition even by those who are the instigators and instruments of change. , we have the problem in any discussion of obsolescence of being too close e technological phenomena taking place to be able adequately to identify .

other troublesome aspect of technological obsolescence which makes our more difficult is the rapidity with which things innovative become nonplace and routinized. I do not remember an era in which there was no transmission but my parents do. I recall a time when there were no sion programs but my daughter does not. Each generation quickly adapts s own technological environment, and the same may be said of "genera-" of computer users.

s is a subtle point perhaps but, I think, an important one. How can we ate the computer as an agent of obsolescence when the introduction of uterized techniques and operations is so quickly and readily accepted? We for granted today the performance of utility billing by the telephone any or the gas company by means of punched cards or optically scannable a with the accounts maintained electronically. Similarly, we know that our king and savings accounts are being maintained by these machines. This is dered routine by consumers and management alike and, indeed, it is in cases. But there was a time less than fifteen years ago when people usly questioned whether it was feasible for computers to perform these . If one had predicted the obsoleting by the computer of the massive al and punched card accounting systems which previously handled these cogent arguments would have been mustered to the effect that such nostications were unrealistic.

d so it is today. Functions viewed as virtually impossible for the computer

inted from *Datamation,* pp. 29-33, January, 1969. Reprinted by permission from F. hompson Publications, Inc., 35 Mason St., Greenwich, Conn. Mr. Head is an active rer, author, and consultant in the computer field.

to accomplish will, in many instances, be so routine in another ten years or so that it will seem ludicrous that these applications were not identified in this discussion. If our past experience with computers is any guide, we should not quickly rule out even the most lurid vistas of the future, remembering how quickly the highly innovative becomes the highly routinized.

Few would question that the computer has, since its introduction on a large scale within business organizations over the past ten years, caused significant patterns of obsolescence of functions, and obsolescence or significant change in the activities of major organizational components within the firm. The extent of computer-generated obsolescence within commercial and industrial organizations has never been fully gauged, though many have bemoaned the impact of "automation" and its displacement of industrial and clerical workers, mostly the unskilled.

One reason it is difficult to assess the impact of the computer is that the growth factor in many firms which are significant users of computers is such that there has been no retrenchment in terms of reductions in force or other measurable cutbacks. A bank, for example, may be serving additional thousands of depositors with the same or even slightly increased clerical staffs and a public utility may be processing many more accounts which, without the computer, could not otherwise have been serviced except with a large increase in office staffs or which, in some cases, could not have been serviced at all without electronic data processing. Thus, many companies have, in the past, been at least partially shielded from the encroachments of obsolescence because their usage of computers emphasized the "bigger bang for a buck" approach in accomplishing routine data processing and control tasks.

Today, the focus of system designers is shifting from the computerization of the high volume and essentially routine tasks such as revenue accounting, demand deposit accounting and payroll to more complex systems to aid in management planning and control. In other words, now that companies have in the main successfully automated their basic transaction recording and processing functions, they are turning to the design and implementation of management information systems. It is my view that the obsolescence generated by these new systems will be much more significant than that rendered by computers in the past.

I propose to consider the computer's role in the obsolescence of business organization and management under these broad categories:

1 Obsolescence at the industry level, where the practices and activities of an entire industry may be significantly affected.
2 Obsolescence within a business organization, regardless of industry.
3 Obsolescence as it affects the administrative and professional skills needed for business management.

INDUSTRY OBSOLESCENCE

While the computer has made enormous inroads in most industries and has significantly impacted day-to-day operations, we have not yet witnessed what may well be a characteristic of computer usage in the future: the obsolescence of entire industries as a result of increasing computerization. Let's consider some possible examples:

CONSUMER CREDIT The American Bankers Association recently established a high level committee on payment systems chaired by the president of a major bank. The term "payment systems" is a sort of banker's "code word" for what has been called the checkless society, and the establishment of this committee suggests the serious intent of the banks to pursue electronic means for transferring funds to replace the billions of checks that presently clear through the banking system. If the bankers succeed, and most experts believe that it is only a matter of time before the electronic payment system will prevail, consumers will make purchases by means of an identifying card inserted into a device at a merchant establishment. The transaction will be recorded on line, with funds from the consumer's account being immediately transferred electronically into the merchant's account. If the consumer does not have sufficient funds in his account to cover the transaction, his bank will make an advance based upon a pre-established line of credit.

Now this new way of doing business will not obsolete the banks or retail merchants, though it will undoubtedly change their methods of operation considerably. But consider the impact on the credit bureau industry. There are several thousand local credit bureaus operating today which serve the merchant community and others engaged in the granting of consumer credit. Their function is to maintain files of credit information so that the credit status of a potential purchaser can be verified by a merchant prior to making a sale. It is difficult to see what the role of such credit bureaus will be in the checkless society, inasmuch as communications will be direct from the merchant to the bank where the consumer maintains his financial relationship, with the bank making its own electronic evaluation of credit status on an up-to-the-minute basis prior to the approval of each transaction.

It is true the credit bureaus themselves are beginning to automate their files of credit information and to coalesce this information into regional data centers. But they are in a race against obsolescence. Eventually their data banks may be integrated into an overall national payment system, thus losing their identity in large part, or they will be bypassed as a result of new relationships between the banking and merchant communities.

PUBLISHING The recent furor over the revision of the copyright laws as they might apply to the storage and retrieval of copyrighted material by means of computerized data banks reflects the growing concern of the publishing industry

over potential obsolescence.[1] A publishing house specializing in technical books now makes a decision on whether to publish a given book based upon careful market analysis of the number of copies that could be sold and the price per copy which purchasers would be willing to pay. Suppose that a given technical work must be projected to sell five thousand copies at ten dollars per copy in order to make a profit for the publisher. If such a text is published and is then inserted in a data bank, the projected sales may dwindle by a sufficient number of copies to make the publisher decide in a subsequent situation of this kind not to agree to publish unless he can project a sale of, say, six or seven thousand, rather than five thousand, copies. This means that certain texts would be rejected with a consequent diminution in the number of acceptable texts and the sales volume therefrom. If this logic is valid, at some point in the future this hypothetical technical book publisher would publish but one copy of a book, and this in electronic form, so that all scholars seeking the information can retrieve it from the publisher's data bank rather than purchase it in hard copy.[2]

It is not by accident that there is growing liaison between the publishers and the computer industry. This takes the form of mergers, such as Prentice-Hall and RCA, as well as the creation of computer-oriented subsidiaries such as CCM Systems by Crowell-Collier-MacMillan. These and other publishers are seeking to exploit new technological developments and transform traditional publishing operations in a manner that will ward off threatening obsolescence.

Another type of publishing company is also vulnerable to the encroachment of the computerized data bank. There are many specialized publishers today who produce hard copy information such as "The Official Airline Guide" which is distributed to travel agents, company travel departments, and airlines and the advertising media rate books which are used by agencies and company advertising departments. It is beyond dispute that computer technology offers a better way of maintaining and distributing this information than the present, frequently updated, massive hard copy volumes. Perhaps we will see these publications go through a period of coexistence like that occurring in computerized stock quotations where both hard copy and on-line information are available. But in the long run, it is difficult to see why such information need be published as at present, when it can be stored and retrieved electronically, with hard copy produced when needed.

FOOD DISTRIBUTION One large supermarket chain is reportedly designing all its new supermarket facilities in such a way that they can, at some future point,

[1] It must be conceded that another technological advance is contributing to this threat to the book industry, namely xerography and kindred methods of reproduction.

[2] It should also be noted that the combination of computerized information storage and retrieval and xerographic reproduction threatens to make obsolete not only the publisher but also the author of a technical book who, failing to gain a publisher for his work, will have to turn to other endeavors in order to make a living.

be converted to alternative uses, such as furniture stores. Far from being an aberration of eccentric management, this type of contingency planning reflects the distinct possibility of computerized control of food distribution in such a way that an entirely different relationship between consumer and distributor could become the accepted pattern. Let us suppose that consumers in a given locale establish with the grocery supplier standing orders for periodic delivery, say weekly, of staples such as eggs, milk, and vegetables and that these are then dispersed by delivery vehicles from a centrally-located warehouse rather than picked up and paid for by the consumer at the neighborhood market. This implies that the consumer would maintain an account with the food supplier, with delivery of items being preprogrammed, giving due recognition to exception conditions. If the quantities needed were to be varied or discontinued, either temporarily or permanently, the consumer would notify the distributor's data bank. Billing would be done automatically, with the distributor's computer tied into the aforementioned banking computer.

Of course, there would continue to be specialty stores which could provide exotic foodstuffs and take care of unanticipated fluctuations in household needs. But this does not obviate the possibility that the supermarket, that hallmark of our affluent society, may be on the way out.

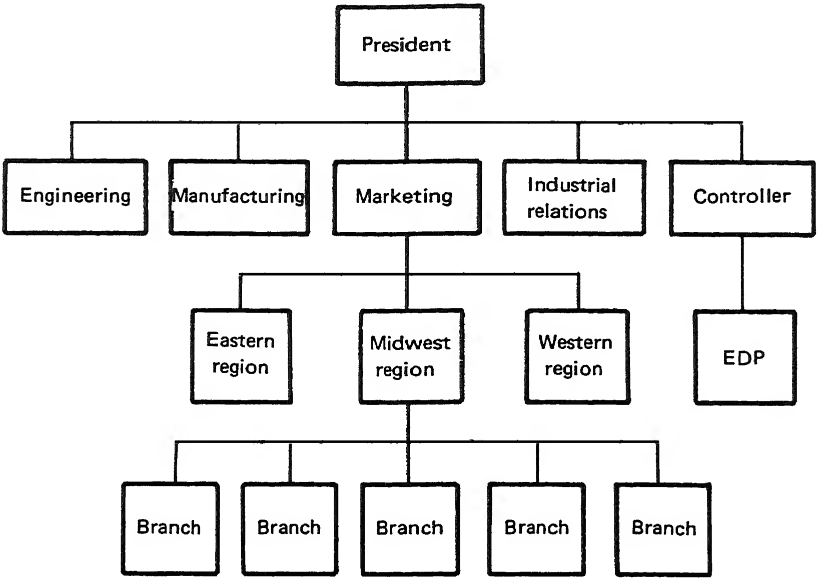
I have tried to suggest by means of these examples that obsolescence will in the future affect whole industries either by eliminating them or by transforming them so radically that they are hardly recognizable in terms of present day operations. Many other examples could, no doubt, be added.

Of course, this type of industrial obsolescence will not occur according to a neatly predictable timetable. Not only will human factors be an inhibiting element in some cases, but the perpetuation of existing business institutions by means of legislation and other methods of public and private protection will probably occur, just as, historically, we have sought to protect certain established institutions and ways of doing business. But the point is still valid that the computer will engender obsolescence in whole industries rather than within the confines of a single company as has largely been the case up to now.

ORGANIZATIONAL OBSOLESCENCE

Turning now to the matter of obsolescence within the firm, irrespective of industry, there are changes taking place which should, in the future, affect traditional alignments of functions and responsibilities which are, in highly simplified form, depicted in Fig. 1. Some of these changes have already taken place within certain companies and will undoubtedly occur in many more as corporate interest and attention shift increasingly away from detailed transaction processing and cyclical management reporting and into the realm of company data bases and on-line management information systems.

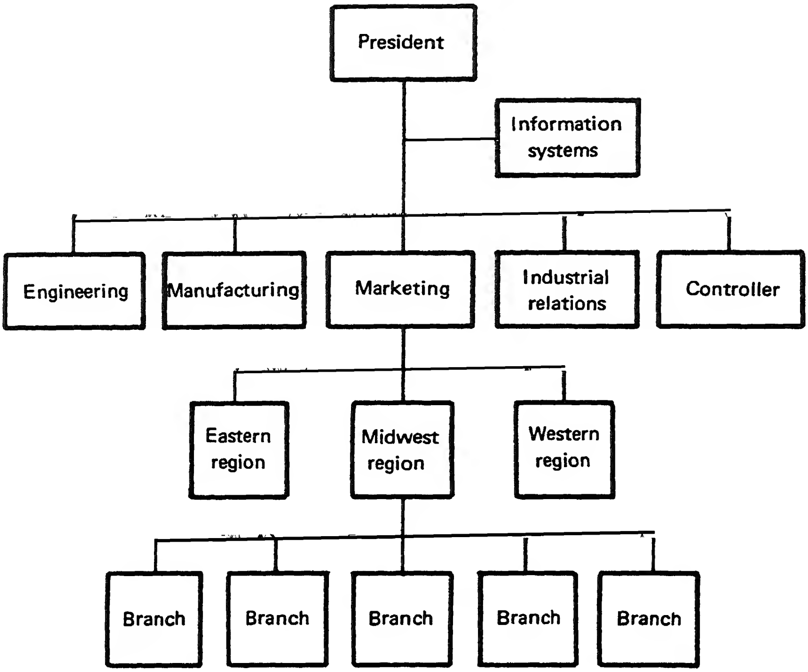
FIGURE 1



UPWARD MOBILITY OF THE SYSTEMS DEPARTMENT When the computer first made its way into company operations, it was usually lodged under the controller, with the department head often reporting to an assistant controller. This is where the tabulating or "IBM" department had always been and, since the computer was to be used for accounting applications, this seemed to be a logical spot for it as well. Recently, though, there has been established in many companies the position of vice president for information systems, reporting directly to the president or executive vice president of the company and outranking the controller in both status and responsibility. In a sense, then, as management gives recognition in this way to the growing importance of computer usage and to the amount of company resources being allocated to computer operations, certain key responsibilities of the controller are fast becoming obsolete. Heretofore, the maintainence of the company books and records and, consequently, the control over the information flow within the company were the exclusive province of the controller. Now these functions are being lodged elsewhere with an attendant decrease in the importance of the controller's department. Figure 2 shows an organization chart modified to reflect the advent of the vice president for information systems.

COALESCENCE OF DEPARTMENTAL ACTIVITIES The initial business applications of the computer were discrete and "stand alone" in nature. For

FIGURE 2

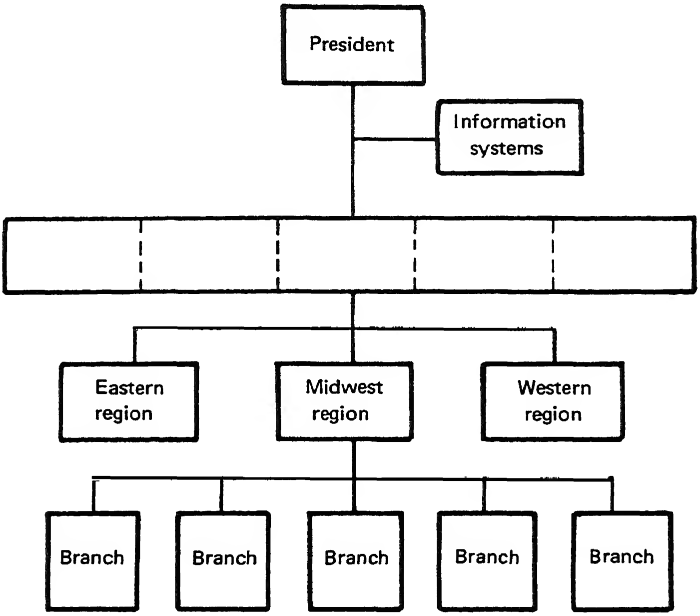


example, accounts receivable might first be designed and programmed, followed by payroll, then perhaps inventory control, and so on. One reason for this piecemeal approach to the development of major applications was that it reflected the organizational boundaries that traditionally existed. An accounts payable system would be designed with the requirements of the "user," e.g., the purchasing department, in mind and a production control system would be designed to reflect the requirements of the manufacturing part of the organization. Most practitioners today regard this approach to computerization as the antithesis of what is commonly termed a "total system" or "integrated system," wherein data elements common to all departments of the company are stored in a single data base and transactions which affect more than one application area are captured but once and then processed in a manner which is appropriate for all users of the information.

But once information is collected in a common data base and the processing of this information is approached from a company-wide standpoint, much of the rationale underlying presently defined organizational boundaries can be seriously questioned. There is an obvious relationship between accounts receivable and accounts payable processing in that each provides information for updating

inventory, with an inventory control system providing the needed link between the two. As such interrelated functions as these are converted to the computer in a reasonably well-integrated manner, the boundaries between the marketing department, the manufacturing department, and the purchasing department in a hypothetical firm becomes less meaningful than in the past. This form of obsolescence, which challenges the traditional separation of organizational components, is suggested schematically in Fig. 3.

FIGURE 3

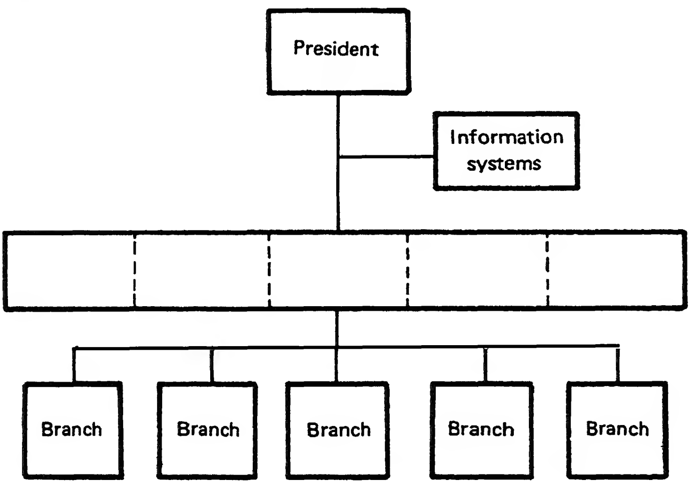


REDUCTION IN ORGANIZATION LEVELS Many companies operating nationally and maintaining a large number of field offices for sales and sales support have evolved into a regional/branch office pattern whereby the country is divided into some three to a dozen or so regions which might, in turn, control one hundred or more branches at a subordinate level. This type of organization has generally worked fairly well in achieving a reasonable degree of decentralization of decision making at the local level, while insulating head office management from all but the more important problems. It will, in the future, however, prove obsolete. With the advent of high speed data links between the branch offices and the head office, there is less and less need for the regional office to serve as a sort of managerial "middle man" by supervising the branches,

reviewing the data generated at the branches and, in general, monitoring their performance. In fact, such regional offices may even serve as a communications block in today's high speed communications-oriented information systems. Results of branch office operations can today be transmitted direct to headquarters just as conveniently and rapidly as to a regional office. At headquarters, performance data can be reviewed, with the aid of large scale computers, and acted upon promptly by head office management whenever exception conditions occur.

Some may regard this development as a swing of the pendulum back towards centralization within the company as a result of the increasing utilization of computers at the headquarters location. I tend to view it as a "flattening" process which reduces the number of levels in organization, as shown in Fig. 4. This same process of obsoleting entire layers in the organizational hierarchy is also taking place within the headquarters itself as well as in the field organization used in this illustration.

FIGURE 4



MANAGERIAL OBSOLESCENCE

When the subject of obsolescence is considered as it affects the responsibilities and prerogatives of company management, the influence of the computer appears in its most disconcerting guise. It is fairly easy to identify skills and activities of lower level management that are now being programmed, just as the activities of clerical personnel were programmed into a computer a generation ago. For instance, the commercial banks first obsoleted the clerks in the

bookkeeping department by converting demand deposit accounting and loan accounting to computers. Now the availability of programs for automatic credit scoring and commercial loan analysis threatens to obsolete at least a portion of the skills still practiced one or more levels above the clerical.

But this upward thrust of the decision making capability of the computer into the area of middle management is only part of the picture. There are more important matters to be pondered which have to do with the duties of top management. In this context, an observation even more subjective than those made elsewhere in this paper may be excusable: most chief executive officers in large companies are men in their fifties and sixties who acquired their managerial skills in the pre-computer era; it is my view that many, if not the majority, of these men do not understand and do not trust the machines installed in their organizations and are too far along in their careers to reach any satisfactory accommodation with them. To put it more succinctly, these executives look forward to retirement before the forces of obsolescence wreak havoc with the kind of corporate existence viewed by them as normative.

Just as a whole generation is now growing up to whom the television set did not arrive as an intruder to displace the accustomed practice of listening to the radio, a new generation of company presidents must, and will, begin to assume responsibility. These will be men who understand the pitfalls and opportunities inherent in computerized information systems; men who, in many cases, are destined to advance from the position of vice president for information systems to the president's chair. In effect, we will witness a sort of necessary and natural obsolescence of management-men too senior to be advocates of radical change in business organization and too inured to traditional business practices to utilize effectively the technological capabilities now at hand.

Beyond this, there exists the more ominous possibility of obsolescence of the company president's function itself, entirely apart from the characteristics of the individual occupying the position. I am referring to the rise of the "technostructure" as a factor in corporate decision making, as described by John Galbraith.[3] It is part of Professor Galbraith's thesis that companies in the new industrial state are governed increasingly in their decision making processes by technically trained managers and professionals working in groups and committees below the level of top management. According to this analysis, major corporate decisions can no longer be made without the participation, or at least tacit acquiescence, of the technostructure because the complexity of the products and services being rendered requires the involvement of their specialized skills. In somewhat exaggerated terms, this implies that the functions of top management are tending to become partly, if not largely, ceremonial in nature with major decisions being achieved by committee action involving members of the technostructure.

[3] John Kenneth Galbraith, *The New Industrial State,* Houghton Mifflin Company, Boston, 1967.

To the extent that this occurs, the importance of the computer as a tool to abet the decision making processes of those in the technostructure must certainly be acknowledged. And if, indeed, as Galbraith asserts, the technostructure comes to play an increasingly significant role, and that of top management a diminishing one, this would be among the most important forms of obsolescence wrought, at least in part, by the computer.

In this brief paper, I have not sought to be exhaustive in dealing with the important matter of computer-generated obsolescence in business organization and management. The subject is a broad one and one not readily amenable to quantitative analyses or even to the achievement of consensus among thoughtful observers. Some may feel that I have overemphasized the importance of the computer as a perpetrator of change. But if we look at the inroads that these devices have already made into the more mundane areas of company operations, we must conclude that the metamorphoses to be encountered in the future will, regardless of their specific character, be far-reaching and profound.

READING 32 DISCUSSION QUESTIONS

1 What industries might become obsolete as a result of increasing utilization of computers?
2 How might computer usage bring about organizational obsolescence?
3 "When the subject of obsolescence is considered as it affects the responsibilities and prerogatives of company management, the influence of the computer appears in its most disconcerting guise." What does Mr. Head mean by this statement?

READING 33 THE COMPUTER: ENGINE OF THE EIGHTIES*

JAMES H. BINGER

The subject of this article presents an issue about which most managers give little time generally, because it requires more than the usual thought, more than the usual amount of commitment, and a degree of planning that the business community—the world's best planners—has yet to master. I am referring, of

*Reprinted from *Advanced Management Journal* of the Society for Advancement of Management, vol. 32, no. 1, pp. 21-27, January, 1967. Reprinted by permission from *Advanced Management Journal*. Mr. Binger is the Board Chairman of Honeywell Inc.

course, to the issue of "information," and the tool that is the great expediter of information—the computer.

Wrapped up as we are with solutions to the immediate problems of business management, managers often fail to take the time to sit back and assess what is going on around them. We look back into the past to find and correct our mistakes and to learn from our achievements. We look ahead in an effort to determine where new opportunities for growth and success lie. We are thoughtful. We tend to be objective, analytical and totally committed to entrepreneurial activities.

But often we also become so involved in the day-to-day problem-solving and risk-taking activities of the entrepreneur that we sometimes overlook the broad-gauge trends taking shape around us.

One of those trends has already developed its form. It is just now learning to spread its wings. Very shortly it will take off and fly. I refer to the "Age of Information" which is already upon us.

Chief among the many products of information handling is the computer. For the computer will become by 1980 what the engine, and all that it implies, is today. It will become the Engine of the Eighties. The primary product, if you will. The product around which businesses operate, society moves, government acts. It will be the economic force—the power plant of productivity. And it will be the propellant of the profound changes that contemplative men sense are soon to come.

Surely the engine has played that fundamental role in recent history. It has been the propellant of massive change in the business, social and economic order.

In its many forms—such as steam, gasoline, electric, jet and rocket-powered—the engine has extended man's ability to conquer new heights. It has stimulated change. And it has contributed mightily to the living standards of the world.

For example, without the engine, there would be no automotive industry, which today, if you include all related suppliers, accounts for roughly 10 percent of the Gross National Product and employs probably an equal percent of the total labor force. The auto industry, we know, is an underpinning of economic health, for its fortunes are directly reflected in the prosperity, or lack of it, in many basic industries.

Productive processes ranging from job shop parts fabricating to assembly line operations literally would be powerless without the application of engines. Motor power is also the backbone of our far-flung distribution and transportation industries, which rely on engines for air, water and overland movement of goods and people.

FUTURE CHALLENGE

As needs changed, and new opportunities appeared, the engine was adapted to meet them. That same analogy applies to the computer, which is now in the

ırliest adaptive stages. We have succeeded in building a nation—and eventu-ly a world—we can hope, in which the provision of basic human needs has ecome largely automatic. The computer will fit that process of automation cely.

But our current situation is hardly Utopian, for the past has always proved at the future will be a challenge. What appears to be changing is the area of nphasis, the direction in which we must head in the future. And here is where e computer's greatest contribution will be made.

Today, in addition to being concerned with man's productive capacity and ith the sustenance of life, we must become concerned with higher levels of ıman need, and it is in filling these needs that computers will play their most tal roles.

These are the needs that make headlines every day. Their existence is part of e modern social drama. They include, in my mind, the whole cloth of human lationships. Let's call them the high-order needs.

OMMUNICATIONS

ıey include, first and foremost, communications. Communications among eople. Among various vested-interest groups. Among governments. When we ink of the growing confrontations of business and labor, labor and vernment, government and business, we gain solid proof of the need for better mmunications. When we observe the confrontation of races, we see the same t of proofs. When we watch the subtleties of the Cold War over a period of 20 ears, we observe how humanity is struggling to solve problems through ersuasion and psychology rather than resort to the dread instruments of war at our modern world has created. Indeed, this new "war for men's minds" is eing waged with the weapons of information.

We can already see that the tools by which this process of communication will carried out are computers. For computers are the tools of information ındling and transmission. They are the engines that will drive us toward faster, ore complete and more factual communications—in business, government and areas of human relations.

Facts can be marshalled swiftly, where in the past only opinions were available resolve problems. Common information pools shared by all vested interest oups can provide the same data to each, with the same swiftness. International mmunications systems will some day eliminate the critical time lag in ansmitting information around the world. These new capabilities will con-ibute toward maintaining an equilibrium of reason upon which the future will epend. Computers and the product of computers—information—will make this ossible.

EDUCATION PROCESS

The second of these high-order needs is highly dependent upon communications and information technology. I am speaking of the education process.

Disparity describes the relationships in world education. The greatest enemy any race or nation or group of people faces is ignorance, for ignorance is a more durable form of bondage than any other. And even in advanced nations, such as our own, where educational facilities more generally are available, refinements of the education process are needed—and coming.

Computers are playing a pivotal role in this renewed effort to broaden educational opportunities and sharpen standards. Already one thousand computers are in use for pupil administration, training and research. They are finding their way into primary and secondary school districts to help allocate facilities, keep records, establish curricula, and perform other nonteaching tasks.

And in the vast virgin territories of vocational training, computers are now being used in administration and in pupil training functions. This is happening now. But the best is yet to come. For if the computer is to be the engine of education, it must become involved in the learning process. And it will.

In the next 14 years—1980 is that close—we can expect to see computer-aided instruction grow tremendously. "Slide-rule" computers, already in test use in several locations, will permit many students to share central computation centers for doing research, scientific and engineering studies. Terminal devices of all types—from visual to printing mechanisms—promise to revolutionize the manner in which classroom instruction takes place. Computer-based libraries will make the vast bulk of the world's accumulated knowledge readily available and classified to support nearly any form of inquiry.

Computers thus used will hasten the learning process, broaden the amount of knowledge available, intensify curricula, and, most important, create a start on knocking down the boundaries of ignorance that now imprison billions of people. This, to me, is a high-order need of future society. The computer will be the device that will hasten its fulfillment.

COMPUTERS AND MEDICINE

The third of these needs is in the field of medicine. The matters of disease, and the things that cause disease—such as air and water polution, insufficient or uncorrelated medical data, the pressures of living in modern society, and the remaining frontiers of unconquered knowledge—face a new tool to overcome them.

Administration of hospitals, of patient care, and of the voluminous mass of medical data is now the province of computers—although current efforts represent only a foot in the door.

Today technology exists to link computers to diagnostic instruments in order to get better, faster, more accurate readings. In Boston, a laboratory study of X-ray enhancement, in which computers break down gray scale in X-rays, has already shown that computers can find tumors too small, or too hidden in tissue, for the human eye to perceive. In hospitals, the nurses' stations, laboratories and even dietetic departments are enlisting computers in their fight to improve patient care.

These are just faltering first steps in the application of computers to medical problems. This is the engine applied in a new way, and people are just now learning to adapt to it and to adopt it. But the direction is clear—the computer will be a partner in the solution of medical problems.

SOCIAL AND PHYSICAL SCIENCES

A fourth area of need is the social sciences and physical sciences.

We can take pride as a nation in the galloping technological and sociological progress made in recent times. Like all radical social or economic advances, the industrial movement—and the engine that spurred it—moved faster than man's ability to adjust to it.

As a result, the headiness of the industrial experiment left in its wake the power of labor unions, the controls of government, and the gnawing suspicion among the business community that, in our eagerness to put this new-found power to work, we must not have done something right.

The social mechanisms that served us during less complex times are no longer adequate. They need revision, restructuring, to adapt them to the high-order needs of society.

The swiftness of the transition from agrarian to technological to information-based societies has created new types of problems, and the computer made its well-timed appearance as a tool that can help solve them. For, by 1980, it will also serve as the engine of progress in social and physical sciences.

More efficient handling of the law processes, for example, is one area of potential computer application. Elimination of congested dockets, better selection and analyses of legal precedents, better administration of the rapidly expanding legal workload and its related data base will be possible by application of computers.

The rehabilitation of criminals and chronic welfare cases, progress in the fields of administration of mental health, accumulation of vital data in professions ranging from archaeology to zoology will add to man's knowledge of history, culture, the order of life, the nature of the universe, and how to deal with social problems. In every one of these fields, computers are at work today. Only time and the talent and imagination of the people involved will limit the horsepower of this engine of social and physical progress in the future.

PERSONAL SERVICE

Which brings me to the fifth and final of these needs, which I will refer to, for lack of a better term, as personal service.

If there is an apt description of the service function today, it might well be a paraphrase of the old weather proverb, "Everybody talks about service, but no one does anything about it."

In using the term "service business," however, I would like to extend it far beyond what we normally consider to be personal services, and into completely new echelons, for I believe such echelons are needed.

As the application of computer power spreads beyond today's bounds, to affect some of the areas I have already mentioned, it will be limited largely by the amount of effort, commitment and people devoted to it. We cannot expect a teacher, for example, to become the computer expert who supports computerized classroom instruction. Nor can we expect the doctor or lawyer to spend precious hours and days in mastering the computers that will serve him. Rather, we must rely on the creation of an entire new support business—a service business in each of these fields—that can act as "information middlemen."

INFORMATION SPECIALISTS

These will be the specialists of information technology who perform the tasks of information collection, processing, analysis and distribution; who design the various new applications to be assigned to computer-based systems in any given field; and who serve as interpreters of the physician's needs, or the teacher's needs, or the lawyer's needs, or the businessman's needs.

Indeed, we have already seen tens of thousands of such people, carrying the titles of "systems analysts," or "programmers" or "applications specialists," appear in business organizations, government agencies, and on campuses and in hospitals. What we have seen is just the beginning. For this entire field of information will require a veritable army of people if progress is to move as fast as potential and technology allows.

As communications-type systems which link computers and transmission networks together continue their rapid expansion into all business, government and social areas, the pressure for these service specialists will continue to grow.

In the next decade, this new field of "information middlemen" will expand to five times its present size. Where today there are approximately 200,000 of these people at work, by 1975 there will be well over a million. Their titles may vary, depending upon their fields of endeavor, but basically they will be the interpreters of information demand.

Where, we can ask, will these people come from? And the answer is—from the productive processes. The changing nature of production jobs being spurred by plant automation promises to free tens and hundreds of thousands of workers

om their repetitive, factory-type labor and put them in the front office erforming service functions. In that sense, we will see history repeat itself. Not ɔng ago our major employment source was agriculture, but that changed with ie industrial revolution. We can anticipate a service revolution of the same type the future.

The signs are there for us to see. The combined pressures of rising personal icome, increasing population, and greater leisure time have put incredible stress n traditional service functions. More and more people are being thrown into ervice positions to meet demands. More and more would be if the people could e found.

These pressures, combined with the need all of us will acknowledge to provide etter levels of service to greater numbers of customers, vendors, and other nportant groups upon whom we depend for the viability of our businesses, romises to create an enormous new employment source in the next decade. nd again we find the computer as the engine that helps create these jobs at the ame time it frees workers from more menial tasks.

It is in those areas that I predict the great progress of the next two decades will ake place. We are dealing with an increasingly complex world that demands a iore thoughtful response from each of us. It is a world that will not ccommodate ignorance or insufficient knowledge. And it will be a world in hich information systems will flourish, and in which the computer will provide ie impetus.

REPARATION IMPORTANT

ust how well are we preparing for this coming era?

Let's first go back into the history of the computer, which this year is 12 years ld as a commercially usable tool. The past 12 years of the computer industry vere much like the first 12 years in the life of the engine. It was a period of ising learning curves, in which men groped for ways to put the new tool to use, ɔr ways to make it perform in various applications, and for devices that could e attached to it to extend its latent power.

Although we are still in the learning phase, there are already 35,000 computers ı use, with a value approaching $10 billion. They are used in virtually every onceivable area of human activity. One journal has classified 1,000 separate ses of computers. In addition, the desks of most computer users are filled to verflowing with new ideas and applications that only a shortage of time, ersonnel and finances prevent from becoming reality.

Furthermore, despite the massive computer capability that exists in the United tates today, it is quite clear that our effective computing capacity could be oubled virtually overnight if users made maximum use of the power that they ave resident in their computer centers.

It is also clear that business firms, in particular, and the government are right now in the process of moving out of the learning period into the period of creative activity.

In a memorandum to heads of government departments and agencies last June, President Johnson acknowledged the future of computers in the following way: "The electronic computer is having a greater impact on what the government does and how it does it than any other product of modern technology. . . . In short, computers are enabling us to achieve progress and benefits which only a decade ago were beyond our grasp. . . . The technology is available. Its potential for good has been amply demonstrated, but it remains to be tapped in fuller measure."

Booz, Allen and Hamilton, the Chicago-based management consulting firm, recently issued a report based on a study of 33 business organizations—ranging in size from $9 billion to $100 million in annual revenues—and discovered that they were shifting from the mundane, learning-type functions to strategic computer usage.

Thus, it seems to me there is a powerful array of evidence to indicate that the computer is ready to enter a mushrooming period of usage. It is an engine that has been tuned and is ready to give maximum performance.

AGE OF INFORMATION

There is a growing chorus of voices acknowledging the fact that this new engine does indeed exist with all its implicit power, and that it will indeed have the impact on the new Age of Information that its predecessors—the various forms of reciprocating jet and rocket engines—have had on the current Age of Mechanization. I think the message for all of us here is clear.

First, the computer demands our greater interest and concern. In the press of daily activities, as I have mentioned earlier, we get so immersed in the past, so busy with the present, and so concerned about the future problems of our businesses that we often don't take time to look beyond and isolate the truly momentous trends taking shape. I suggest that the computer is one of those trends, and it will demand from all of us more than casual or superficial interest.

Second, whether we sense it or not right now, the computer will play as significant a role in our individual and business lives in the future as the engine in its many forms has played in the past. We might wish to ask ourselves if we have begun to prepare for that eventuality.

Third, the computer will help open as many new business opportunities tomorrow as past technology has occasioned today. And it will reap obsolescence in the same fashion for many businesses that are alive today. The questions of "What new opportunities?" and "What obsolescent businesses?" are questions that directly affect you and me. Greater familiarity with the engine

of change—the computer and information technology—can help give us good answers.

Finally, if the computer does indeed become the Engine of the Eighties, it will require good mechanics, good drivers and careful use. It will need visionaries who are capable of applying it wisely to real problems. It can truly be said, "Don't leave computers to the technicians. They are too potentially valuable, or dangerous." Unless business leaders start now to get involved, to climb aboard at the early stages of this trip, we will be doing just that. We will be abdicating our role of influencing, shaping and guiding the directions that these powerful new tools might take.

I think those directions can carry all of us to new heights of success and achievement. So climb aboard, and let this powerful new engine carry you into the new Age of Information. It promises to be a very rewarding ride.

READING 33 DISCUSSION QUESTIONS

1 (a) What role will computers play in education?
(b) In medicine?

2 "The computer will become by 1980 what the engine, and all that it implies, is today." Discuss this statement.

3 Five high-order needs are discussed by the author. Identify these needs and explain how the computer will help satisfy them.

SUMMARY OF CHAPTER 8

Although batch processing will continue to account for the bulk of the work done for some time to come, there is today a trend in the direction of the judicious use of quick-response management information systems. In the next decade there will be substantial growth in the number of large timesharing facilities. Several hardware, data-transmission, and software trends are intimately associated with the growth of timesharing systems. The majority of the timesharing systems installed in the next five years will be primarily for the use of single organizations. But more "information utilities" will be established and will prove to be economical and successful.

In the next five years companies will increase their efforts to find ways and means of consolidating data-processing activities into broader and more integrated systems. Firms will increasingly seek to define and classify basic data commonly so that better integration will be possible. Eventually, it is likely that data systems will regularly cross company lines and be linked together by compatible computer networks. The "cashless society" may be a reality by 1980.

Managers will face a rewarding and challenging future—*if* they plan and prepare for it. They will have to make decisions in a more complex and dynamic setting, and they will have less time to react to problem situations. But they can have access to higher-quality information upon which to base their decisions.

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